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Quarterly Progress Report

Division 6

15 March 1958

Digital Computer (U)

ASTIA 301951
AFCRC-TN-58-1012

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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HEADQUARTERS
NORTH AMERICAN AEROSPACE DEFENSE COMMAND
PETERSON AIR FORCE BASE, COLORADO 80914-5001

#1778

REPLY TO ATTN OF: J30S

26 NOV 1984

SUBJECT: Classification Review "Quarterly Progress Reports"

TO: ALFL (Lincoln Laboratory)

1. In response to ALFL letter, 28 Nov 83, the (11) confidentia documents titled "Quarterly Progress Reports - Division 6 - Digital Computer" and dated 15 Jun 1954 through 15 Dec 1958 hav been reviewed. Recommend the documents be declassified in whol since the sage system computer no longer exists and information contained in the documents no longer has an effect on national security.

2. To officially declassify these, documents, the 416L Securit Classification Guide OPR, which is at HQ Sacramento Air Logisti Center, McClellan AFB, CA (MMCM), must be contacted with the recommendation to declassify.

JOHN E. MOORS, LCOL, CF
Ch, At Sensors Division

Memo for Record 14 Dec 84

Talked, by phone, with Ed Smalden, Sacramento ALC/MMCM, McClellan AFB, CA. Based on the recommendation in this letter he considers these documents declassified.

THOMAS J. ALPERT, MAJOR, USAF
CHIEF, ESD LINCOLN LABORATORY PROJECT OFC

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ELECTRONIC SYSTEMS DIVISION (AFSC)
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731

REPLY TO ATTN OF: ALFL (Lincoln Laboratory) 17 Dec 84

SUBJECT: Declassification of Lincoln Laboratory Documents

TO: Mr. M. Wesley/A-109
Security Office
Lincoln Laboratory

1. Reference your letter of 17 Nov 1983 requesting declaassification and public release of MIT Lincoln Laboratory Quarterly Progress Reports issued between June 1952 and December 1958 (see atch 1).

The first major hurdle of this process has been cleared. Attachment 2 authorizes the declassification of the following documents:

"Quarterly Progress Reports - Division 6 - Digital Computer"

15 Jun 1954 (C)-(LL # 1, C315172C)
15 Sep 1954 (C) (LL # 1, C315189C)
15 Sep 1956 (C) (LL # 1, C315208C)
15 Mar 1957 (C) (LL # 1, C315206C)
15 Jun 1957 (C) (LL # 1, C315253C)
15 Sep 1957 (C) (LL # 1, C315254C)
15 Dec 1957 (C) (LL # 1, C315255C)
15 Mar 1958 (C) (LL # 1, C315256C)
15 Jun 1958 (C) (LL # 1, C315257C)
15 Sep 1958 (C) (LL # 1, C315258C)
15 Dec 1958 (C) (LL # 1, C315313C)

The next major hurdle is obtaining public release. This will be done through ESD Public Affairs (Mr. John O'Brien).

ORIGINAL SIGNED BY

THOMAS J. ALPERT, Major, USAF
Chief, ESD Lincoln Laboratory Project Ofc

2 Atch
1. Lincoln Laboratory Ltr, 17 Nov 1983
2. NORAD Ltr, 26 Nov 84

Cy to: D. Murphy/B-107 w/atch
W. Hill/L-339 w/atch

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Quarterly Progress Report

Division 6

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The Air Force Declassification Office concurs in the marked classification.
Date: 5-2-14 Reviewer: 137

Issued 16 October 1958

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Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

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DIVISION 6 HEADQUARTERS

DIVISION HEAD

R. R. Everett

ASSOCIATE DIVISION HEAD

J. F. Jacobs

STAFF ASSISTANTS

C. W. Farr
J. C. Proctor

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DIVISION 6 SUMMARY

Thirty-one test periods were conducted in the Experimental SAGE Sector. Almost half of these used live aircraft. Initial tests of the SAGE non-real-time (SNORT) simulation will begin next quarter and shakedown tests of BISEPS II, a real-time simulation involving the BOMARC IM-99A will continue. About 40 proposed design changes to the initial SAGE System were evaluated and major increases in 1960 SAGE capability were designed. The first transistor-driven core memory was successfully completed and a second and larger one is being assembled.

Thirty-one test periods were conducted in the Experimental SAGE Sector (ESS) of which 13 used live aircraft: 11 were shakedown, 6 were evaluation, 12 were for operator integration, and 2 were special demonstrations.

Preparations were begun for the integration of Texas Tower 2 (TT-2) and time-division data link in ESS.

Plans were drafted to begin tests of the SAGE non-real-time (SNORT) simulation during the next quarter. Assembly tests were completed and shakedown begun of BISEPS II, a real-time simulation of an air situation involving the BOMARC IM-99A written by IBM with Lincoln assistance for the AN/FSQ-7 (XD-2) at Kingston. A working group was formed to produce a SAGE-BOMARC system description based on the IM-99B missile.

Based on an assumed system load, a study concluded in this quarter predicts a 200-300 track capacity for the 1959-60 SAGE System.

Proposed changes to the design of the initial SAGE System will be evaluated by the newly formed Initial SAGE Problem Committee consisting of representatives of several Lincoln Laboratory groups, System Development Corp., IBM, and the 4620th ADW. Approximately 40 design changes were examined by this committee during the quarter.

The major increases in capability of the 1960 SAGE System were designed. They include: AA operation, BOMARC IM-99A, century-series interceptors, emergency capability (Mode II), and Mark X Selective Identification Feature (SIF).

The first transistor-driven core memory (TDCM) has been tested and is ready to be wired into the TX-0 experimental computer in preparation for its transfer to MIT. A second and larger TDCM is under construction for the TX-2 computer now being assembled.

Progress in the studies of magnetic materials is now being reported in detail in "Lincoln Laboratory Quarterly Progress Report, Solid State Research," Groups 24, 35, 37, 63, and 310 (Unclassified); a summary of Group 63 work is included herein.

R. R. Everett
Division Head

J. F. Jacobs
Associate Division Head

15 March 1958

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TECHNICAL INFORMATION RELEASES

1 December 1957 – 28 February 1958

TIR	Release Date	Material Released
1-228	2 Dec. 1957	2M-0827, "Experimental SAGE Sector Requirements for Air Force and Army Operator and Maintenance Technician Support," dated 5 November 1957.
1-229	9 Dec. 1957	"BTL-Lincoln Report on Output Circuitry for SAGE UHF Receivers," dated 6 December 1957.
1-230	13 Dec. 1957	6M-3851-5, "Master Reference List of Equipment Specifications for XD-1," dated 17 October 1957.
1-231	13 Dec. 1957	IBM Document S-154-1: Revision of S-154: "Specifications that are Applicable for AN/FSQ-7 Combat Direction Central, AN/FSQ-8 Combat Control Central and Santa Monica," dated 30 October 1957.
1-232	31 Dec. 1957	2M-0853, "Orientation of Heavy Radar Sites by Solar Radiation," dated 17 December 1957.
1-233	14 Jan. 1958	6M-5426, "System Office Recommendation: Radar Data for IND Situation Display Consoles (SOER No. 101)," dated 9 December 1957.
1-234	15 Jan. 1958	6M-5441, "System Office Recommendation: Height-Finder Message Format of the DCA Program," dated 20 December 1957.
1-235	15 Jan. 1958	6M-5418, "System Office Recommendation: DCA Program, Height Quantization (SOER No. 93)," dated 9 December 1957.
1-236	21 Jan. 1958	6M-5297, "System Office Recommendation: Implementation of SAGE/Missile Master Integration in the Washington Sector," dated 20 December 1957.
1-237	21 Jan. 1958	2M-0841, "Range Calibration of Data Processing Machines at SAGE Heavy Radar Sites," dated 12 December 1957.
1-238	1 Feb. 1958	6M-5414, "System Office Recommendation: Crosstell Clock, AN/FSQ-7, AN/FSQ-8, XD-1," dated 30 December 1957.
1-239	14 Feb. 1958	6M-5475, "System Office Recommendation: Security of Teletype Line Carrying Air Division Weapons Status Summary (SOER No. 249)," dated 14 January 1958.

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TABLE OF CONTENTS

Division 6 Summary v
Technical Information Releases vi
List of Illustrations viii

SYSTEM DESIGN – GROUP 61

A. Summary 3
B. Simulations 3
1. SNORT (SAGE non-real-time) 3
2. BISEPS II (BOMARC Interceptor SAGE Experimental Program) 4
C. Weapons Assignment Study 4
D. SAGE-BOMARC Working Group 5
E. Manned Interceptors 5

ESS INSTALLATION – GROUP 62

A. Summary 9
B. Subsystem Integration 9
1. Texas Tower 2 9
2. Time-Division Data Link 9
C. Coordination of ESS Maintenance 10
1. Manual Input Console Switches 10
2. Utility Diagnostic Active (UDA) Program 10
D. Airborne Long Range Radar Input (ALRI) Study 10
E. Magnetic Memory and Coincidence Detector 11
F. AN/FSQ-7 (XD-1) Performance 13

ADVANCE DEVELOPMENT – GROUP 63

A. Summary 17
B. Memory 17
1. TDCM 17
2. TX-2 Assembly 19
3. Thin Film Engineering 21
Appendix 22

ESS SHAKEDOWN TESTING – WWI AND MTC OPERATION – GROUP 64

A. Summary 27
B. ESS Shakedown: Phase II 27
1. Test Plans 27
2. Test Results 29
C. Memory Test Computer 31
D. Whirlwind I 31

VACUUM TUBES – GROUP 65

A. Summary 35
B. Display 35
1. Charactron 35
2. Scriptrons 36
3. Typotron 36
C. Receiver Tube Development and Engineering 36
D. Research 37
1. Controlled Persistence Tube 37
2. Tonotron Life Test 37
3. Solid-State Displays 37

SPECIAL STUDIES – GROUP 66

A. Summary 41
B. CHARM System Description 41

ADVANCE SAGE PROGRAM DEVELOPMENT GROUP 67

A. Summary 45
B. Program Cost Evaluation of 1959-60 SAGE 45
C. AMIT: A Computer-Synchronized Recording Program for Radar Data 46
D. SNORT-TWS 46
E. Dual Tracking 47

SYSTEM OFFICE – GROUP 68

A. Summary 51
B. The Initial SAGE Problem Committee 51
C. Model 2 of the DCA Program 52
D. The 1960 SAGE System 52
1. SAGE Operation with AADCP's 52
2. SAGE Control of BOMARC IM-99A 53
3. Manned Interceptors 53
4. Mode II (Emergency) Capability 53
5. IFF (Mark X) Selective Identification Feature (SIF) 54
6. The SAGE System Training Program (SSTP) 54

ADMINISTRATION AND SERVICES – GROUP 60

A. Summary 57
B. General Engineering 57
1. Equipment for Low-Temperature Studies 57
2. In-Out Equipment for TX-2 and TX-0 57
C. Card- and Tape-Processing Facility 58
D. Whirlwind I (WWI) 58

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LIST OF ILLUSTRATIONS

61-1.	The semi-automatic commitment mode.	6
62-1.	Schematic diagram of magnetic coincidence detector.	12
63-1.	Block diagram TDCM.	16
63-2.	TX-2 system schematic.	18
63-3.	TX-2 instruction word structure.	18
63-4.	TX-2 plug-in units, lug mounting at left, eyelet mounting at right.	19
63-5	Thin film sense amplifier block diagram.	20
64-1.	ESS system tests performed, 1 December 1957 – 28 February 1958.	28
64-2.	Breakdown of ESS system testing time.	29
66-1.	Information flow for CHARM system.	40
60-1.	Metal helium dewar.	56
60-2.	High-speed tape transport for use with TX-2 computer.	58

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SYSTEM DESIGN

GROUP 61

MORRISS, B. E., *Leader*

McVICAR, K. E., *Associate Leader*

BOYD, H. W.
CLEVELAND, W. L.
DOMINITZ, J.
EARNEST, L. D.
GLATFELTER, G. L.
GOLDBERG, S. H.
GOODMAN, H.
HARVEY, R. B.
HAUSER, S. J., JR.
JEFFERY, L. R.
LADD, D. W., JR.
LAFFERTY, MARY E.
LITSIOS, S.
MAYER, R. P.
PHELPS, M. M.
PINKERTON, D.
SHAY, J. W.
SHOOLMAN, A. R.
SINESI, P. N.
VANCE, P. R.
WALTMAN, P. E.
WILLIAMS, H. W.
WOLF, E. W.

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I. SYSTEM DESIGN
GROUP 61

A. SUMMARY

In continuing participation with IBM, Boeing, and other groups, Group 61 brought the SAGE non-real-time (SNORT) simulation, including the simulated aircraft radar data (SARD) program, to the assembly testing stage. Plans were drafted for initial tests to begin next quarter. BISEPS II, a real-time simulation being written for AN/FSQ-7 (XD-2) by IBM with Group 61 assistance, was assembly tested and began shakedown at Kingston. A study of the weapons assignment function resulted in proposals for changes to the SAGE DCA (direction center active) program which will increase the rates at which target assignment and weapons commitment can be made: new displays and switch actions will provide more flexibility in the transmittal of information to operators and to airbase personnel. A working group was formed to produce a SAGE-BOMARC system description based on the IM-99B missile.

B. SIMULATIONS

1. SNORT (SAGE non-real-time)

The SNORT simulation is being written for an IBM 704 computer by Lincoln Laboratory, IBM, and Boeing to examine SAGE automatic tracking and guidance functions. BOMARC will be the first weapon simulated, followed by manned interceptors and other missiles.

During the quarter the two major groups of SNORT programs, TWS (track-while-scan) and WGT (weapons guidance and tracking), were brought to the following states of completion:

(a) TWS: Group 67 completed the writing and assembling of the programs. The package will be tested upon completion of SARD, the program which supplies TWS with a simulated aircraft radar data input (see below).

(b) WGT: Assembly testing of the package was begun, although three out of five of the subprograms required further checking out.

The simulated aircraft radar data (SARD) program, which is to be the input to TWS, was beginning to make successful tapes on a limited basis at the end of the quarter. This program is also to be used with the BISEPS II simulation on the AN/FSQ-7 (XD-2) at IBM-Kingston.

Plans for conducting multiple-flight tests with SNORT were completed in draft form. The detailed report will be found in 6M-5483, "Initial SNORT-TWS Test Plan for Parallel and Crossing Tracks," by M. M. Phelps, 11 February 1958. Each test will consist of a number of runs of 150 aircraft flights each, and each run will be divided into 75 independent situations involving a pair of aircraft tracks moving parallel to each other or crossing. Some of the parameters to be varied are:

(1) Simulated Radar Input (SARD)

aircraft speeds: 300, 500, 700, 900 knots
blip-scan ratio: 0.7, 1.0
crossing angles: 15, 30, 65 degrees
separation of parallel tracks: 1, 3, 5, 10 miles

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(2) Tracking Program (TWS)

noise (returns/radar/scan): 0, 240
radar coverage: single and double
tracking logic and constants: initial and modified SAGE

2. BISEPS II (BOMARC Interceptor SAGE Experimental Program)

BISEPS II is a real-time simulation to verify the design of the operator-machine relationship in the initial tactical integration of BOMARC with SAGE and to evaluate system performance. IBM-Kingston is preparing the simulation for use on AN/FSQ-7 (XD-2) with assistance by Group 61.

During the quarter, the assembly testing of BISEPS II was completed and on 17 February system shakedown began. The program cycled successfully during several exercises in which the SARD tape (see SNORT) furnished simulated radar data. Shakedown and modification of BISEPS II will continue during the next quarter.

C. WEAPONS ASSIGNMENT STUDY

Modifications have been proposed* to the SAGE DCA program to increase the rates at which target assignment and weapons commitment can be made. The proposed changes are intended to supplement, rather than change, the specifications for BOMARC, manned interceptors and AA weapons. Displays and switch actions, however, undergo significant modifications.

Three basic changes are proposed for the weapons assignment functions:

(1) The senior director and senior weapons director have additional facilities to assign targets to weapons directors. The senior weapons director may assign individual targets or target areas to specific weapons directors by standing operating procedure, assign specific targets by switch action, or permit the computer to assign targets automatically by area and load.

(2) The weapons directors may use one of three options in the commitment of weapons against targets: manual commitment, semi-automatic commitment, or automatic commitment. Manual commitment is essentially unchanged from the initial system. Under the semi-automatic option the computer automatically presents sequential displays to the weapons director on his tracks. The weapons director may approve the computer's recommendation, modify the commitment against the track, or commit weapons against an entirely different track. In the automatic commitment option, the computer automatically selects individual weapons and commits them against the weapons director's assigned targets. Each weapons director has console facilities for his own choice of option; but the use of this facility may be governed by standing operating procedure.

Under all three options the computer will automatically select an intercept director if none is specified by the weapons director.

* To be published as 6M-5613-1, "Target Assignment and Weapons Commitment," by J.W. Shay and P.N. Sinesi.

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(3) An automatic scramble facility is provided for communication with the manned interceptor bases. Whenever a commit action is taken by the computer program or a weapons director, the computer program will prepare and transmit a teletype message with the scramble orders. An automatic reply-back for airborne reports and modification of weapons status information is planned, but provision for operation without the reply-back is included.

The weapons assignment proposal is undergoing review by the System Office, Group 68.

D. SAGE-BOMARC WORKING GROUP

In December a working group was formed to produce a SAGE-BOMARC system description as a preliminary step in the formulation of an ADC employment plan for the BOMARC IM-99B. The committee, headed by a representative of Group 61, includes Groups 25, 42, 45, 61, 67, 68, Boeing, ADSMO, the 4620th ADW, and SDC. In addition to coordinating the group's efforts, Group 61 is participating in the description of SAGE-BOMARC communications, tactics, weapons direction, and emergency capability and will prepare a summary system description. The IM-99B has several features which make it possible to increase the air defense capability of SAGE over what can be achieved with the IM-99A. In a normal environment the major additional features of the IM-99B are: an increase in range from 200 to 400 miles, an increase in altitude coverage from 10,000-70,000 feet to 0-75,000 feet, and the replacement of frequency-division data link by time-division data link. In an ECM environment the major additional features of the IM-99B are 1) an ECM-resistant doppler seeker which sees farther, has the ability to operate to the ground, and has search-while-go capability; and 2) the ability to store, before launching, all commands necessary for full flight.

E. MANNED INTERCEPTORS

Detailed operational and mathematical specifications for improved manned interceptor capability in SAGE were nearing completion at the end of the quarter. The aircraft covered are the F-101B, F-102A, F-104A, and F-106A. The specifications are planned for publication next quarter in six documents:

6M-4490-1 "Improved SAGE Manned Interceptor System" (a summary of the system) by L. R. Jeffery, P. R. Vance, L. D. Earnest, P. N. Sinesi, H. Hickey (IBM), and P. E. Waltman.

6M-4491: "Notation, Functions, and Manual Inputs," by H. Hickey (IBM) and P. E. Waltman.

6M-4492: "Voice, Data-Link, and Crosstell Communications," by P. E. Waltman.

6M-4493: "Weapons Assignment Facilities," by P. N. Sinesi.

6M-4494: "Intercept Direction Facilities," by P. N. Sinesi and D. B. Yntema (Group 38).

6M-4495: "Guidance and Fuel Computations," by L. D. Earnest.

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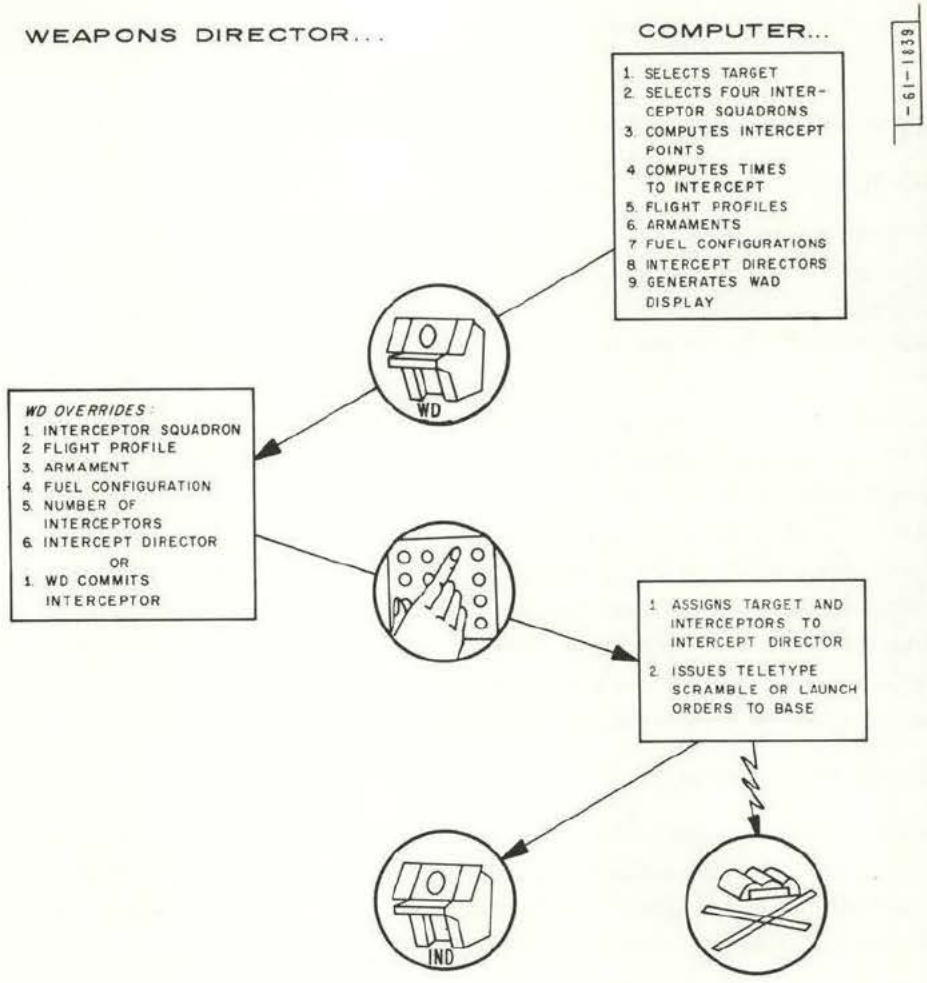

Fig. 61-1. The semi-automatic commitment mode. The computer will select "under-commited" targets and present these on a weapons assignment display (WAD) to the weapons director. The WAD will recommend four squadrons (manned interceptors and BOMARC) for commitment. The weapons director may change some of the items on the WAD or he may commit one of the squadrons present on the WAD. When the weapons director commits an interceptor, the computer will issue scramble or launch orders to the base automatically and assign the interceptor and target to an intercept director. The semi-automatic commitment mode will be the normal mode of operation during medium or medium-heavy battle conditions.

ESS INSTALLATION

GROUP 62

O'BRIEN, J. A., *Leader*

CANTY, W. J., *Associate Leader*

FALLOWS, R. S., *Associate Leader*

ARONSON, I.
BARRETT, B. W.
BUNTING, J. H.
CALLAHAN, R. J.
CARTER, C. J.
COFFIN, S. T.
CRANE, J. D., JR.
CURRIER, J. R., JR.
DURGIN, F. R.
FLANAGAN, M. J.
GERHARDT, R. H.
HINGSTON, A. J.
IRISH, F. E., JR.
JAHN, R. C.
MALOUIN, J. A.
MARNIE, L. G.
SANDERS, C. W.
SANDY, G. F., JR.
SANDY, T. J.
SMALL, C. E., JR.
SWEENEY, F. J.
WERLIN, A. M.

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II. ESS INSTALLATION
GROUP 62

A. SUMMARY

Preparations were begun for the integration of Texas Tower 2 (TT-2) and time-division data link in the Experimental SAGE Sector (ESS). The coordination of ESS equipment maintenance continued: the replacement of manual input switches on 40 consoles reduced trouble reports significantly. The development of a real-time diagnostic program continued. The possibility of a seaward extension of SAGE radar coverage was investigated and one live test was conducted. A magnetic memory and coincidence detector of large capacity and simple design was designed.

In a joint effort with other Lincoln Laboratory groups, Group 62 assisted in the preliminary steps toward setting up four communication and three data links between TT-2 and ESS. In another combined effort, the group wrote a program to test the time-division data link output section when IBM has completed its installation.

The replacement of manual input switches on all ESS consoles was begun and some 40 consoles were completed: the new switches are more reliable, reduce switch trouble reports, and make the diagnosis of other equipment and program failures easier. A system of programs to diagnose computer failures in real time continued, and the trial use of a short routine in a training test yielded encouraging results.

An investigation was begun of the technical problems of airborne long range radar input (ALRI) into SAGE. ALRI would extend low and high altitude radar coverage to the seaward approaches of the U.S. A preliminary comparison of ESS and AEW radar data from a special live test indicated some of the problems to be overcome.

B. SUBSYSTEM INTEGRATION

1. Texas Tower 2

Plans were made and specific responsibilities assigned to connect Texas Tower 2 (TT-2) to ESS. The connections will include four voice circuits (two for communication with strike and interceptor aircraft) and three digital data circuits, all via tropospheric scatter to shore terminals. The radar data, also used by SAGE direction centers of the Boston Sector, will be converted in South Truro to the Lincoln Laboratory type data service for transmission to the ESS Direction Center. The data and communication links are expected to be completed early next quarter and the subsystem is scheduled for its first use in ESS shakedown testing about 1 June.

2. Time-Division Data Link

Preparations for the integration of time-division data link (TDDL) in ESS were begun. A test team headed by Group 25 was formed to plan subsystem integration tests and to draw up the specifications for them. Group 62 wrote a program to test the output section, presently being installed by IBM: the program will generate valid, bad parity, and incomplete messages, send them through the output section, and return them through a closed loop for verification. Subsystem testing is expected to begin in July when the output section, the ground-to-ground phone line link, the transmitters, and the receivers are installed.

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C. COORDINATION OF ESS MAINTENANCE

Group 62 provides liaison between the users of ESS and those responsible for maintaining ESS equipment. It provides the users with a system that has been tested and which has the desired program operating in the computer. Test programs and special test equipment are devised to ascertain that the system is operating properly or to locate malfunctions in it.

1. Manual Input Console Switches

The manual input switches (pushbuttons) on some 40 consoles in the direction center were replaced with new switches of improved design. Group 62 had initiated the request for this refitting because of numerous complaints received over a long period of time from the operators: the original switches frequently did not make electrical contact, and operators had no immediate way of knowing whether their manually inserted actions were transmitted or not. The design for the new switches was developed by the Oak Switch Co. under IBM contract. In the consoles where the new switches have replaced the older type, there has been a substantial decrease in the number of switch trouble reports. Diagnosis of other equipment or program failures has also been made easier, since the switches can be virtually ruled out as a possible source of trouble.

2. Utility Diagnostic Active (UDA) Program

The writing and verification of a system of programs to diagnose computer failures in real time continued: The utility diagnostic active (UDA)* system is a joint effort with IBM and the SDC Program Development Group. During the quarter a control program (UDC) and a recording program (UDR) were verified separately and operated together successfully. A short routine of UDA, written by IBM to detect memory and drum parities, was operated experimentally with the DCA program during some ESS operator training tests with encouraging results. In the next quarter the component programs will be assembled and tested with a copy of the DCA program.

D. AIRBORNE LONG RANGE RADAR INPUT (ALRI) STUDY

A Lincoln Laboratory study group, in which Group 62 is represented, began investigating the technical problems associated with the extension of high and low altitude radar coverage in the seaward approaches to the continental U. S. Such coverage would support the requirements of air surveillance, identification, and weapons control (especially of the IM-99B missile) in the post-1961 SAGE air defense system. Because the radar-equipped aircraft would perform data processing functions similar to those of present SAGE LRI (long range radar input) sites, the name airborne long range radar input (ALRI) has been given it. Radar returns and ALRI navigational data would be filtered by an automatic digital data processor (in function like the AN/FST-2 at present LRI sites) and sent automatically to SAGE direction centers by line-of-sight, burst transmission.

On 11 February a test was conducted to obtain a detailed comparison of the data from an

* Quarterly Progress Report, Division 6, Lincoln Laboratory, M.I.T. (15 December 1957) Sec. II, C.3.

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AEW aircraft with data from ESS, LRI radars. An AEW Constellation (WV2) aircraft carried a modified AN/APS-70 radar; the ESS system consisted of the South Truro and Jug Handle Hill LRI sites and the AN/FSQ-7(XD-1) computer using Model 1 of the DCA program. A target aircraft flew in various directions relative to the AEW aircraft and to ESS. An analysis of the resulting data revealed probable errors in 1) the operation of navigational equipment, 2) calibration of the airborne PPI scope, 3) the time reference between the computer program and the AEW aircraft, and 4) other unidentified sources. A range-dependent range error was observed, as was a 3/4-mile bias between north and southbound runs: when these deviations were removed from the data, 80% of the range comparisons showed agreement within ± 1/2 mile. Azimuth errors drifted during the test, the peak to peak amplitude of the drift curve being about 3 degrees. The spread of data about the drift error curve was about 3/4 degree. Future tests will be designed to isolate the sources of azimuth errors and to reduce the navigation and range errors as much as possible.

E. MAGNETIC MEMORY AND COINCIDENCE DETECTOR

A memory device of simple design and operation is being investigated: it will permanently store a large number of binary words and will give an immediate indication whether any of the stored words matches a given word read into it. Transformer cores with uncritical characteristics comprise the storage element: there are two cores ("zero" and "one") per bit. A word in the memory is represented by the pattern of a single wire passed through one of the cores in each pair. The number of words corresponds to twice the number of wires that can be fitted through the cores; since the hole of the prototype core measures about 1/4 by 1/2 inch, the number of wires can be on the order of 2500. A prototype model has been constructed with a word length of 10 binary bits.

The operating principles of the memory and detector are illustrated in Fig. 62-1. The top row of transformer cores represents "ones," the bottom row "zeros." The wires strung through the cores represent the stored words: in the illustration the single word in storage is 0011101101. When a word is received for comparison, the cores are pulse driven according to its binary combination (toggle switches provide the manual input in the test model). If the received word is identical to the stored word, the circuit is such that the pulsed cores will be those through which the stored word (wire) does not pass: having received no induced voltage, the stored word (wire) will lack an output pulse. This absence of a pulse, indicating coincidence, is detected by a diode mixing circuit and appropriate amplifiers.

Many other modes of operation are possible which may be useful for certain applications:

(1) the stored words may be subdivided into groups and an indication given of which group or groups contain the coincident word.

(2) the level of the detector may be adjusted so that an indication is given if there is a stored word which differs from the received word by not more than one, two, or n bits.

(3) if the diodes are replaced by resistors, an output is obtained which is a measure of the average correlation

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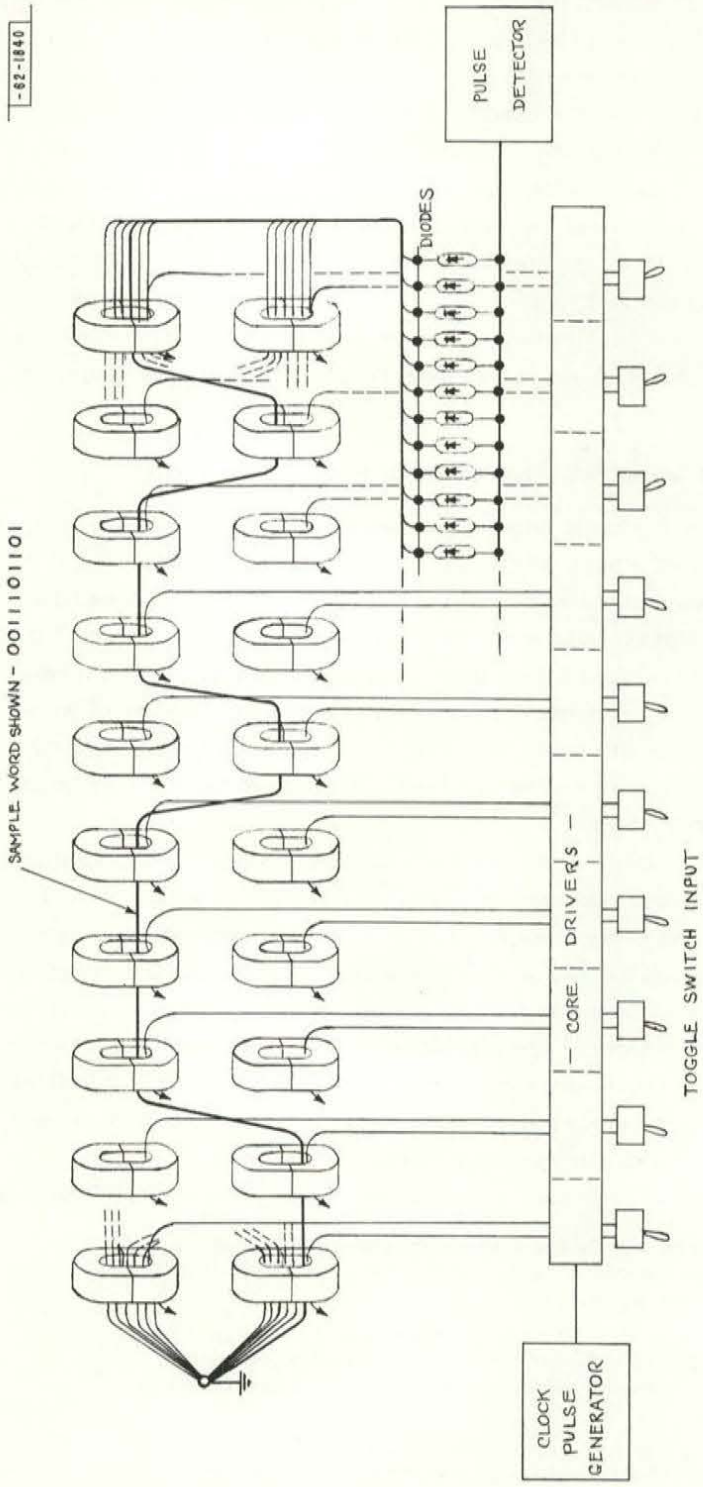

Fig. 62-1. Schematic diagram of magnetic coincidence detector.

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of the received word with all of the stored words in each of the subgroups.

(4) different values of resistors can be used to give different weighting factors for correlation to the words in the subgroup.

(5) nonlinear resistors could perform more complicated installations, such as root-mean-square, and, combined with the other features above, might perform certain functions associated with pattern recognition.

F. AN/FSQ-7(XD-1) PERFORMANCE

AN/FSQ-7(XD-1) performance during its use in December and January by Group 64 and the System Development Corp. was as follows:

Total Computer Hours	465.78
Per cent Good Time	91.6
Mean Free Time (Hours)	8.49
Average Lost Time per Interrupting Incident (Hours)	.68

The figures are given for the computer and its input-output equipment but not the displays and manual inputs keyboards. Since February the performance figures have been gathered and internally reported by IBM.

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ADVANCE DEVELOPMENT

GROUP 63

PAPIAN, W. N., *Leader*
CORDERMAN, C. L., *Associate Leader*
GOODENOUGH, J. B., *Associate Leader*

ARNOTT, R. J.
BARCK, P. E.
BEST, R. L.
BRADSPIES, S.
CLARK, W. A., JR.
COWGILL, URSULA M.
CROWTHER, T. S.
DAVIDSON, G. A.
DOWNING, J. L.
DUGGER, C. O.
DWIGHT, K., JR.
ECKL, D. J.
ELLIS, D. H.
EPSTEIN, M. A.
FADIMAN, J. R.
FARLEY, B. G.
FERGUS, PATRICIA A.
FERRETTI, A.
FLETCHER, J. W.
FORGIE, J. W.
FRANKOVICH, J. M.
GILMORE, J. T., JR.
GOULD, R. H.
GUDITZ, E. A.
GURLEY, B. M.
HERNDON, T. O.
HUBER, E. E., JR.
JOHNSON, T. G.
JOHNSTON, R. C.
JOSEPHS, J. J.
KIRK, C. T., JR.
KONKLE, K. H.
LARSON, E. G.
LIN, C. S.
LOEB, A. L.
MADDOCKS, F. S.
MENYUK, N.
MITCHELL, J. L.
MOON, R. M., JR.
NEUMANN, L.
PETERSON, H. P., JR.
RAFFEL, J. I.
SARLES, F. W.
SAVELL, R. E.
SHOULDERS, K. R.
SMITH, D. O.
UNDERWOOD, D. I.
WEISS, G. P.
WICKHAM, D. G.
WOLD, A.
ZIEGLER, H. L.
ZIEMAN, H. E.
ZOPATTI, R. C.

GROUP 63

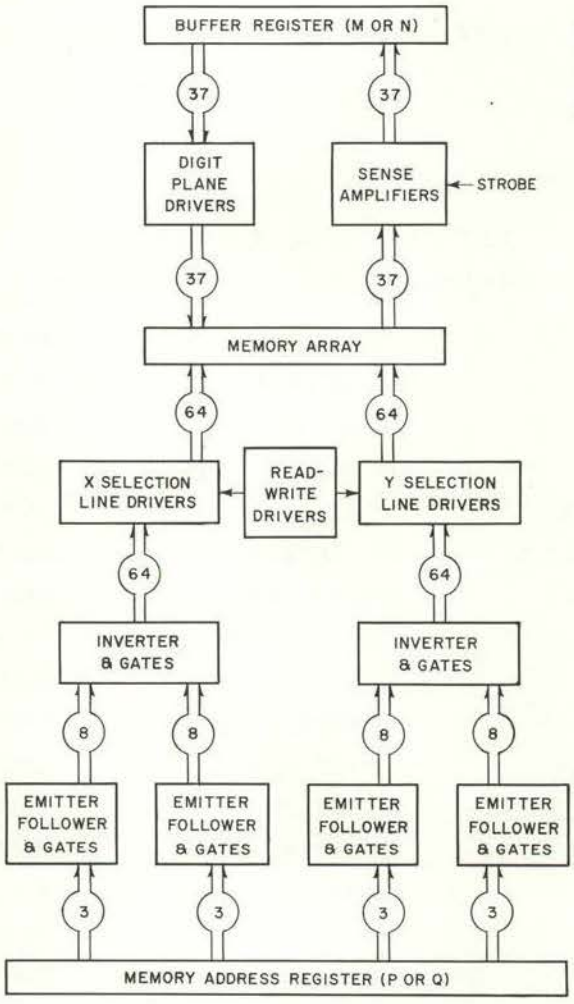

Fig. 63-1. Block diagram TDCM.

III. ADVANCE DEVELOPMENT
GROUP 63

A. SUMMARY

The 19-plane, transistor-driven core memory (TDCM) for the TX-0 experimental computer has been tested and is ready to be wired into the computer. A similar TDCM is under construction for the TX-2 computer which continued to be assembled. Significant additions during the quarter included decoders for the toggle switch memory and for the address portion of the 256^2 memory. The complete E-register (exchange register) and its driver control were mounted and passed tests for full 36-bit operation.

TX-2 machine configurations will be stored in a thin-film memory with a capacity of 32 10-bit words. Experiments are being designed and performed to determine the important factors which must be controlled to obtain uniform and reproducible films. Among the questions to be answered are: the melt temperature dependence of iron-nickel compositions; the cause of random skewing of the easy axis of magnetization from the direction of the d-c deposition field; and the effects on the wall coercive force of the various cleaning agents used in the preparation of the glass substrates on which the films are evaporated.

A thin-film sense amplifier design has been completed. The operation of the amplifier is independent of memory noise and is relatively insensitive to voltage and current variations. A plug-in package for this amplifier is now being planned.

In preparation for the transfer of TX-0 to MIT, a more versatile distribution system for the in-out frame, a new display system, and a photo-electric tape reader have been added.

An appendix to this report to be found on p. 22 presents the summary of progress of the Magnetic Materials Section of Group 63. The complete report will be found in Quarterly Progress Report, Solid State Research (1 December 1957 to 28 February 1958) Lincoln Laboratory, MIT, Groups 24, 35, 37, 63, 310 (Unclassified).

B. MEMORY

1. TDCM

The TDCM which replaces the 256^2 memory in the TX-0 has been completed and tested. Within the next few weeks it will be wired into the computer. The TDCM for TX-0 is a $64 \times 64 \times 19$ stack of 50 mil O. D. $\times$ 30 mil I. D. cores driven by transistors. Repetitive access time will be about 6.0 microseconds.

A similar TDCM (Fig. 63-1) with 37 planes is under construction for the TX-2 computer. During the assembly of the TX-0 stack some undesirable features of the method of interconnecting the planes became evident. With the objectives of reliability and ease of assembly and disassembly in mind, improvements will be incorporated in the TX-2 stack. Typical of these improvements are the drive line terminal frames, one of which will be placed between each memory plane to provide convenient eyelets in which to solder the x and y wires in the assembly stack.

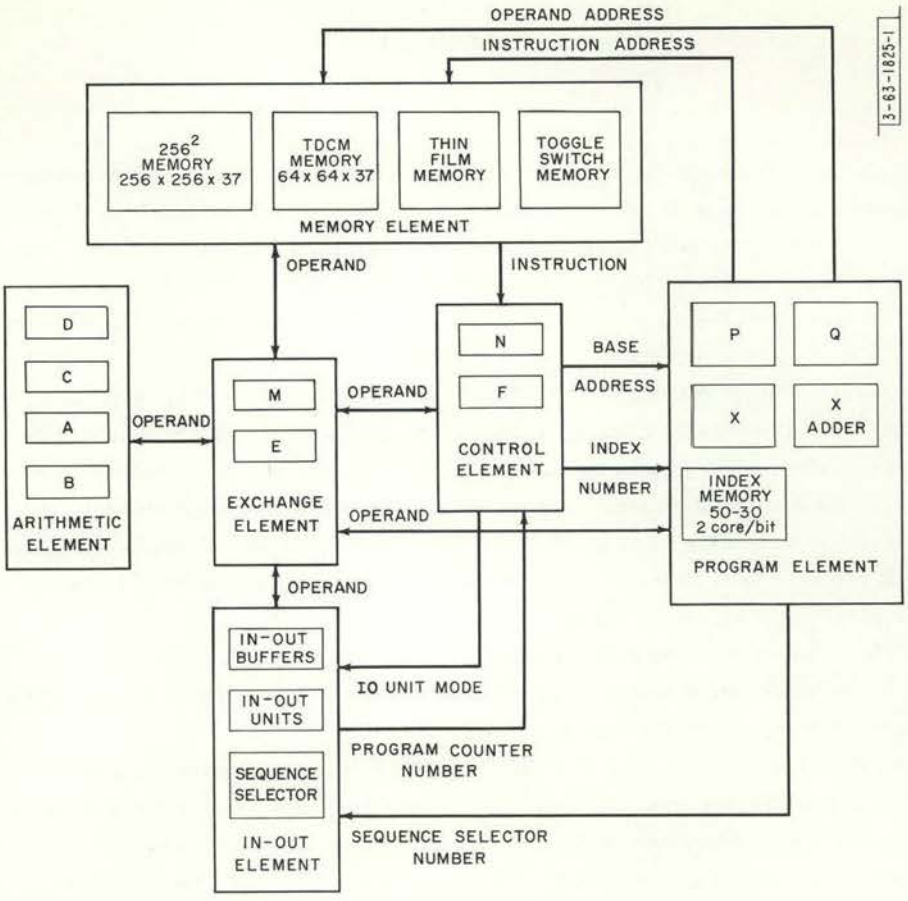

Fig. 63-2. TX-2 system schematic.

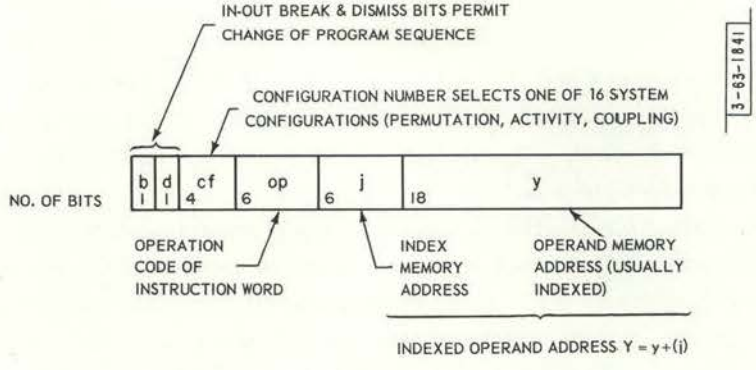
IN-OUT BREAK & DISMISS BITS PERMIT CHANGE OF PROGRAM SEQUENCE
CONFIGURATION NUMBER SELECTS ONE OF 16 SYSTEM CONFIGURATIONS (PERMUTATION, ACTIVITY, COUPLING)
3-63-1841
NO. OF BITS
b 1
d 1
cf 4
op 6
j 6
y 18
OPERATION CODE OF INSTRUCTION WORD
INDEX MEMORY ADDRESS
OPERAND MEMORY ADDRESS (USUALLY INDEXED)
INDEXED OPERAND ADDRESS Y = y+(j)

Fig. 63-3. TX-2 instruction word structure.

2. TX-2 Assembly

Progress in the assembly of the TX-2 computer (Fig. 63-2) continued. The complete E-register (exchange register) and its driver control have been mounted and passed tests for full 36-bit operation. In addition to the installation of decoders for the toggle switch memory and for the address portion of the 256^2 memory, several other sections of the computer have been mounted and their operation verified:

QKIR and PKIR ops	–	these are the sections of the P and Q counter instruction registers which specify to the computer what operation is to be performed.
JD EF-8 net	–	the emitter-follower plug-in units for the J decoder which specifies the machine configuration to be used.
Memory Selector Control	–	the circuitry for the first two digits of the P register which specify the memory from which the instruction is to be obtained.

All of the plug-in units for toggle-switch storage, variable delay circuits, and pulse transformer packages have been tested. The tests disclosed many instances of poor electrical contact because the solder lugs were improperly seated. These difficulties will be avoided in subsequent plug-in units by the use of swaged eyelets in place of lugs (Fig. 63-4). Component leads will pass through the eyelet before being bent and soldered to the printed wiring.

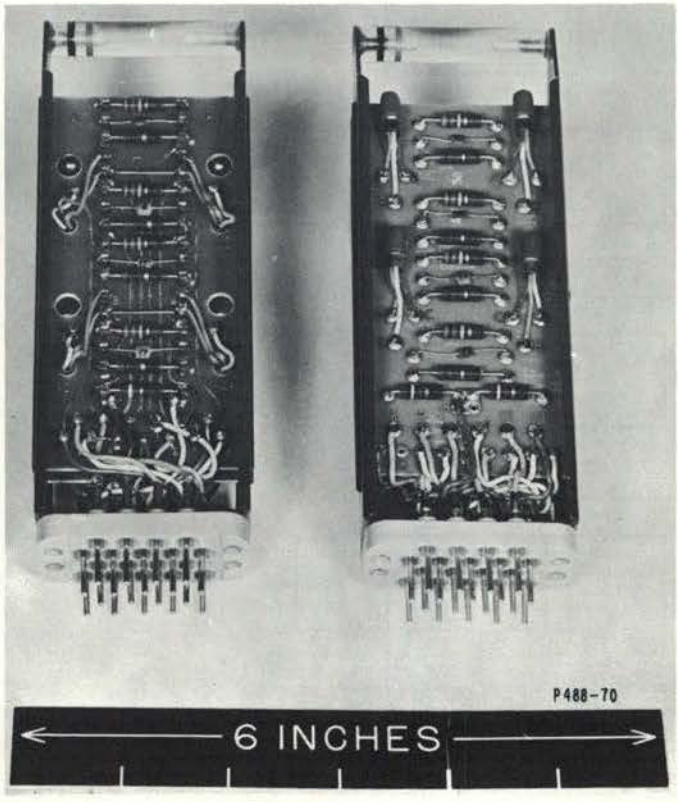

Fig. 63-4. TX-2 plug-in units, lug mounting at left, eyelet mounting at right.

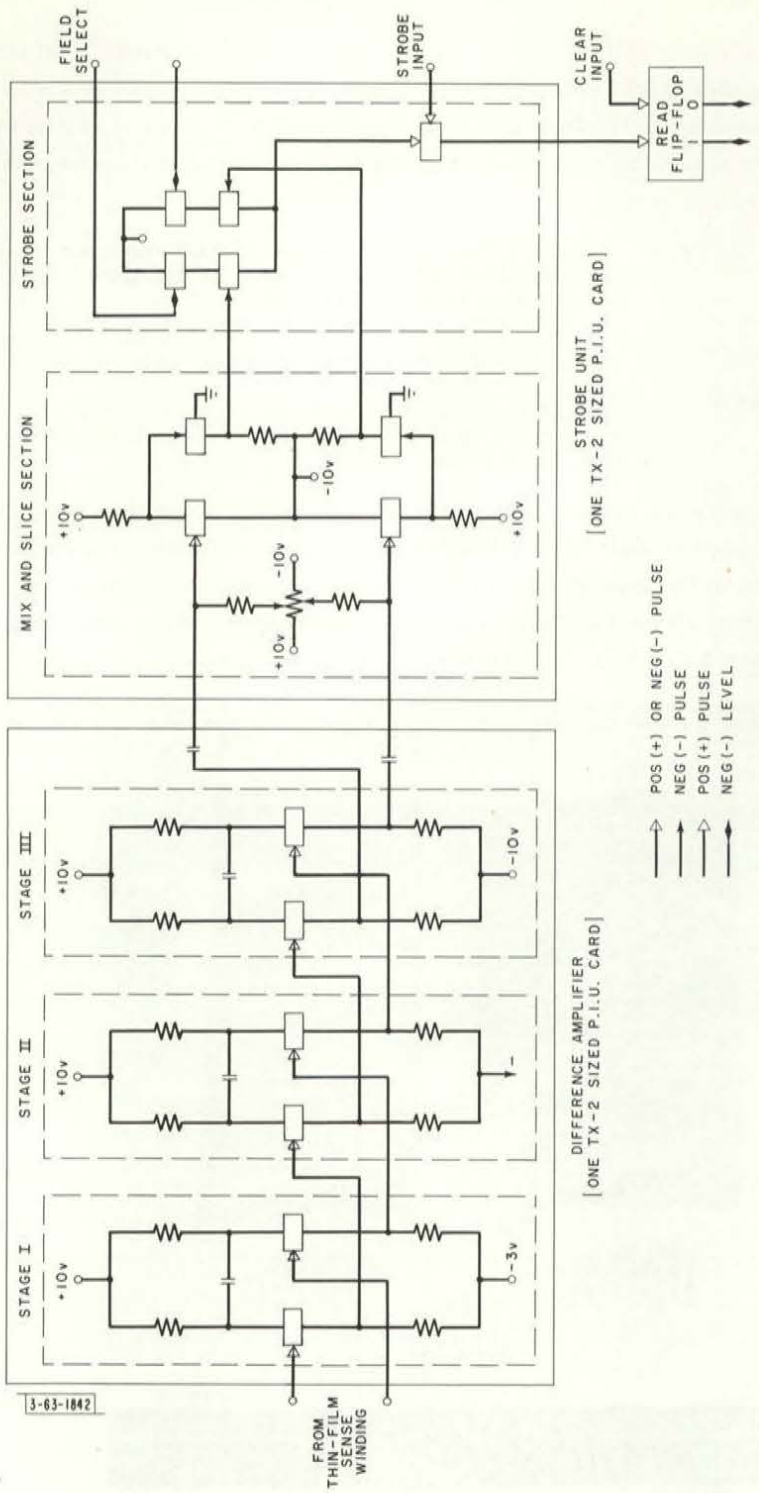

Fig. 63-5. Thin film sense amplifier block diagram.

Several new plug-in units have been designed for low-speed circuitry and these are being laid out on etched wire cards. They include:

Capacitor diode gate used to form a positive pulse from a waveform which is rising from –3 volts up to ground.

Clamped inverter package used to perform logic associated with the in-out equipment and for driving cables to and from the in-out frame.

0.3 μsec pulse former used to form 3 volt triggering pulses from a positive-going wave front.

Dual flip-flop Mod II used to provide logic levels of ground and –3 volts for in-out equipment.

3. Thin Film Engineering

It is planned to store the TX-2 machine configurations within the control element in a thin film memory with a capacity of 32 10-bit words. Preparation of thin permalloy films of uniform and reproducible characteristics continues to be an unattained goal. There is, for example, a considerable difference of opinion among investigators in the field as to the temperature dependence of Fe-Ni melt compositions. In the permalloy range (83% nickel, 17% iron) Speiser of Ohio State obtained results which indicated for every 100°C increase in melt temperature a 5% iron enrichment while the experiments of Morse of the Bureau of Mines indicated a nickel enrichment of less than 0.5%. Experiments relating H_k, the anisotropic field, to melt temperature tend to substantiate the latter figure.

Random skewing of the easy axis of magnetization by up to ±10° from the direction of the d-c deposition field has been observed on 8 × 8 arrays of permalloy films evaporated on thin (6 to 9 mil) glass plates. There is some evidence that the skew results from strains in the glass substrate. More tests will be made to establish the cause of this phenomenon.

A number of experiments have been run to determine the effects on the wall coercive force of the various cleaning agents normally used to prepare the glass substrates on which the films are deposited. Substrates prepared by immersion in Strong's solution consisting of nitric acid and stannous chloride with or without concurrent ultrasonic vibration were cleaner and exhibited wall coercive forces appreciably above those of slides cleaned with acetone or detergents alone. Subsequent experiments showed that stannous chloride was the agent in Strong's formula which increased the wall coercive force. The exact mechanism which causes this phenomenon is not yet known.

A thin film sense amplifier (Fig. 63-5), and its associated logic have been completed. It is a flexible circuit with operating characteristics independent of memory noise, and it introduces a delay of less than 45 millimicroseconds from memory to flip-flop. Operating margins have shown the circuit to be relatively insensitive to voltage and current variations. Present efforts are directed to the design of a plug-in package which will not introduce undue component interaction in spite of the high component density required.

The preparation of TX-0 for transfer to MIT continued. In addition to the TDCM, a number of other modifications are being introduced to convert the TX-0 to a general purpose research tool. A versatile distribution system for the input-output frame has been designed to facilitate connection of various types of input and output equipment to the computer. A display system and photo-electric tape reader are in the process of being checked out.

GROUP 63

APPENDIX
SUMMARY OF MAGNETIC MATERIALS SECTION*

This report covers the period from 1 December 1957 through 28 February 1958.

VII. MAGNETIC MATERIALS

Work has continued on the problem of obtaining a deeper understanding of the relationship between chemistry and the fundamental, intrinsic properties of magnetic materials. Experiments on the crystallography, chemistry, and magnetization of the system $Co_{3-x}Mn_xO_4$ indicate that the magnetic coupling in tetragonally distorted spinels is more complex than the simple A-B coupling originally proposed by Néel to explain the magnetic properties of the ferrites. Studies of the crystallographic properties of several perovskite-type oxides has revealed that there may not be complete miscibility between orthorhombic and rhombohedral perovskite-type compounds. Also, another perovskite-type system containing Mn^{3+} ($LaCo_xMn_{1-x}O_3$) appears to be ferromagnetic, whereas no perovskite containing Fe^{3+} has yet been found which is either ferrimagnetic or ferromagnetic. It was hoped to obtain a ferromagnetic Fe^{3+} - Cr^{3+} interaction, but apparently the Fe^{3+} ion remains randomly distributed over the lattice so that the sign of this interaction is not determined. Application of ligand-field theory to two chromium-containing spinels suggests that the constraints of the stable spinel structure may induce unanticipated valence states. Finally, the extension of the ligand-field theories to metals continues to suggest a promising new approach to the band structure of the transition metals and their alloys.

The development of practical materials for microwave devices has concentrated on processing procedures which optimize density and minimize Fe^{2+} content. High-resistivity, high-density, polycrystalline garnets with line widths of ~50 oe have been prepared. A process for the preparation of a ceramic, stoichiometric $NiMn_2O_4$ has been developed.

The vibrating-coil magnetometer was used to measure the liquid-helium magnetization and Curie temperature of the many new materials which were prepared for magnetic and crystallographic investigation. The study of the crystalline anisotropy of a single crystal of nickel-iron ferrite has revealed that third-order terms are important for this crystal and may be important for all ferrites. The instrument is being equipped to make paramagnetic-susceptibility measurements.

Considerable effort was also expended in the preparation of a digest of the literature on magnetism for the National Bureau of Standards. Over 460 references were reviewed.

VIII. THIN MAGNETIC FILMS

The work on thin magnetic films has concentrated on two important problems: (1) what are the factors which determine the magnitude of the rotational coercive force H_k, and (2) what is the origin of the lack of uniformity in H_k. In an attempt to produce low-H_k materials, isotropic films were prepared by an anneal in a perpendicular magnetic field. The chemical variation

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* cf. Lincoln Laboratory Quarterly Progress Report, Solid State Research, Groups 26, 35, 37, 63, 310 (Unclassified), 1 May 1958.

between films with non uniform H_k produced in a single run was reexamined by a method which does not depend upon chemical analysis, and attempts to make films by electrodeposition were initiated.

IX. TRANSISTORS

A symmetrical core-switch transistor which meets the specifications for the Transistor-Driven Core Memory which is being constructed for the TX-2 computer of Group 63 has been developed by the Philco Corp. working in conjunction with Lincoln Laboratory. After a 1000 hr. life test, this transistor looks very promising.

ESS SHAKEDOWN TESTING – WWI AND MTC OPERATION

GROUP 64

RICH, E. S., *Leader*

DAGGETT, N. L., *Associate Leader*

ALCOTT, W. S.
AUFDERHEIDE, D. R.
BLACK, M. D.
BRIDGE, H. P.
BROOKS, EMY P.
BUZZARD, R. D.
CAMPBELL, JEAN B.
CASE, A. W.
DECOF, D. N.
EARL, LOIS M.
GATES, E. K.
GILL, E. P.
GILLIS, C. V., JR.
GRANDY, C. C.
HODDER, J. C.
HOLMES, L. L.
HOPKINS, F. W.
HUGHES, A. D.
HURVITZ, J. H.
JONES, N. T.
KINNEY, G. C.
LAFFERTY, E. L.
MERCER, H. F.
MONAHAN, J. H.
MORRISON, D. A.
MURPHY, P. J.
NICHOLS, J. R.
NORCOTT, L. H., JR.
OCKENE, N. J.
PETRINO, A. R.
REED, G. C.
ROBERTS, J. E.
ROBERTS, T. A.
ROWE, A. J.
SCHIMELFENYG, D.
SLAGLE, J. R.
STOCKEBRAND, T. C.
WOODWARD, W. B.

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IV. ESS SHAKEDOWN TESTING – WWI AND MTC OPERATION
GROUP 64

A. SUMMARY

Thirty-one test periods were conducted in the Experimental SAGE Sector (ESS), of which thirteen used live aircraft: 11 were shakedown, 6 were evaluation, 12 were for operator integration, and 2 were special demonstrations. Model 1 of the direction center active (DCA) program was introduced to shakedown testing. Emphasis was placed on testing the raid forming, crosstell, and overlap tell functions; the gap filler radars were made available for evaluation testing. The maintenance of the Memory Test Computer (MTC) continued: MTC maintained a heavy load of ESS test data reduction while its reliability was considerably improved. The responsibility for maintaining Whirlwind I (WWI) was transferred to Group 60.

Shakedown tests were hampered because of frequent cancellations of live aircraft due to bad weather. Simulated aircraft and recorded data were used in the majority of tests, and program verification was retarded. Raid forming and overlap telling were tested and found to function properly. Crosstelling, which can be done within ESS by means of program and equipment modifications, will require further testing before satisfactory operation can be obtained. The four gap fillers in ESS registered well among themselves and also with the returns from long range radars. Two preliminary attempts to measure the performance of the system under ECM conditions were inconclusive, but they were helpful in furnishing information to the designers of live ECM tests scheduled for next quarter.

The preventive maintenance time on MTC was extended and the use of the computer was restricted mainly to the reduction of ESS test data: as a result, all performance figures were improved and reliability averaged 96.8%.

B. ESS SHAKEDOWN: PHASE II

1. Test Plans

Group 64 conducts tests in ESS for system shakedown, system evaluation, and operator integration. In addition, the group prepares programs for simulated-data inputs, reduces data recordings necessary for the support of testing, and analyzes data resulting from the shakedown tests.

The objectives of shakedown testing during this quarter were to:

(1) verify the proper operation of Model 1 of the DCA program
(2) test the raid forming, crosstell, and overlap tell functions
(3) test the use of gap filler radars in tracking and weapons direction at low altitudes
(4) improve the proficiency of the operators.

Evaluation of the system is made by Group 22 from data collected in more comprehensive tests designed by Group 64 to measure the performance of the entire system. The results of evaluation tests in this period are reported in the Lincoln Laboratory Technical Memorandums, "Experimental SAGE Sector Quarterly Evaluation Report," TM66-2 and TM66-3.

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Test No.	Data Input Type	Times Performed	Primary Functions Tested
			SHAKEDOWN
II,2	Live	1	Gap fillers, height finders, low altitude interception
II,2A	Live	2	Similar to II,2
II,4	Simulated	3	Crosstelling; preliminary tests
II,7	Simulated	2	Raid forming
II,9	Live	1	Identification and tracking of multiple flight-size targets
II,9A	Mixed	1	Similar to II,9
I,10	Mixed	1	(An evaluation specification adapted to shakedown for one test only)
			OPERATOR INTEGRATION
OIST-5*, 6,7,8	Simulated	11	All operator sections; track loads varying from moderate to heavy
OTE-1†	Simulated	1	All operator sections; strike aircraft maneuvers and air battle situations more realistic than OIST's

*Operator integration shakedown test.
†Operator training exercise.

EVALUATION

Test Date: No.	Strike Penetrations		Peak Strike Load	Interceptor Sorties		Peak Track Load
	Live	Sim.		Live	Sim.	
13 Dec: I,11	12	8	14	18	0	*
12 Dec: I,12	8	8	14	15	0	82
29 Jan: I,16	15	0	14	9	0	*
5 Feb: I,17	16	4	15	21	0	80
12 Feb: I,18	8	10	10	8	8	45
26 Feb: I,20	16	13	18	24	0	70

*Figures not available.

Fig. 64-1. ESS system tests performed, 1 December 1957 – 28 February 1958.

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Improved proficiency of ESS operators is gained in tests using simulated aircraft. Beginning on 24 February, a more realistic environment was provided in the first of a new series of training exercises based on live radar data. The exercises, which provide varying work loads for all operators, are conducted by the 6520th AC&W Squadron.

2. Test Results

Thirty-one test periods were conducted during the quarter: 11 were for shakedown (6 using live aircraft), 6 were for evaluation (5 using live aircraft), 12 were for improving the proficiency of ESS operators, and 2 were special demonstrations of the system. The tests performed are described in Fig. 64-1, and a breakdown of testing time is given in Fig. 64-2.

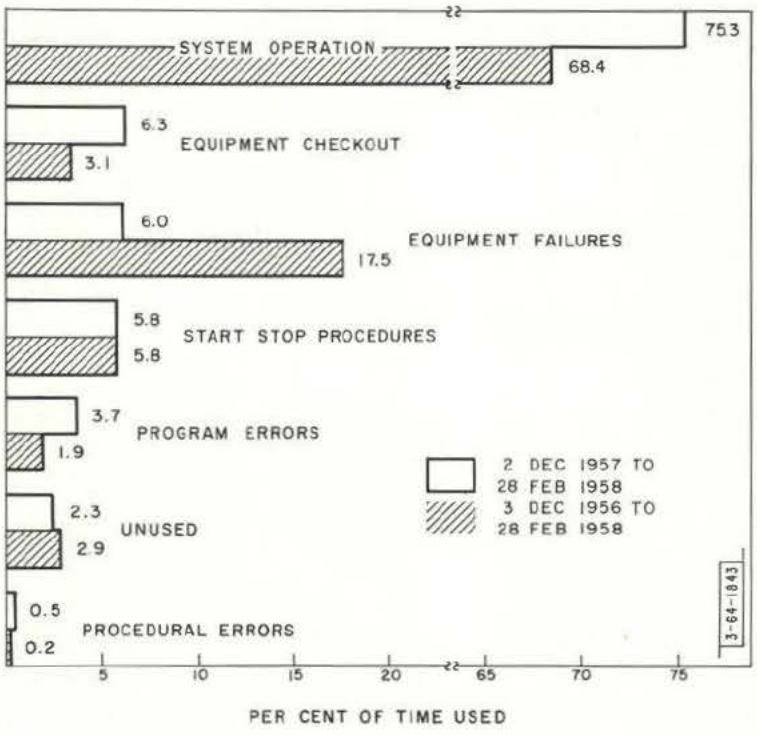

Fig. 64-2. Breakdown of ESS system testing time.

Bad weather, which caused the cancellation of live tests, hampered shakedown and evaluation testing during December and January. In particular, the verification of Model 1 of the DCA program was slowed considerably by the infrequency of live interceptions, and live testing under ECM conditions was prevented. Another significant handicap was encountered in February when the Strategic Air Command issued an order prohibiting the use of live interceptions against SAC aircraft. Although the restriction was modified later in the month to permit approaches of not less than 2 miles, it continued to hamper the verification of Model 1, especially the corrections to the automatic tracking and intercept direction functions. Limited data was obtained by conducting simulated interceptions of live strikes and by directing live interceptors against simulated

strikes, and such program verification as was possible with simulated and recorded inputs was carried on.

a. Raid Forming

Raid forming is performed by the air tactics officer: he recognizes individual tracks whose heading, speed, and proximity to each other indicate a number of aircraft acting together as a unit and by switch action he causes these to be grouped by the program. Most of the program problems encountered in this function were corrected and by the latter part of the quarter the air tactics officer was able to form satisfactory raids with a system load of over 50 strike aircraft entering the system at a rate of about 2 per minute.

b. Crosstell and Overlap Tell

Verification of the crosstell and overlap tell functions continued throughout the quarter. Crosstold track information is that which is passed automatically from one SAGE direction center to another; overlap-told track information is that which is passed from a SAGE direction center to an Air Defense Command manual direction center. Program and equipment modifications had been made to enable AN/FSQ-7 (XD-1) to act as both sender and receiver in the testing of the crosstell function in ESS, but satisfactory operation of the function was not obtained. Overlap telling performed satisfactorily with live aircraft tracks in four tests during which track information was passed to the Montauk Air Defense Control Center and back again to ESS. Testing of both the crosstell and overlap tell functions will continue in the next quarter.

c. Gap Filler Radars

Shakedown of gap filler radars was completed on 21 February when the performance of the gap fillers, their associated equipment, and the program was considered good enough for use in evaluation testing. The four sites are located at Derry, New Hampshire, Chestnut Hill, Connecticut, and Scituate and Halibut Point, Massachusetts. The registration of the returns was good among the gap fillers and with the returns from the South Truro, Bath, and Montauk long range radars. Compared with South Truro returns, for example, the over-all positional difference of the aircraft returns in two tests was 0.55 nautical miles. A study of the data from the three gap filler tests conducted showed that aircraft were being tracked by the automatic tracking function with good stability. An analysis of the weapons direction function was not conclusive, since most of the strikes did not make realistic inbound penetrations. With the completion of gap filler shakedown tests, it was planned to extend their range from 32 to 48 miles in order that evaluation testing would have gap fillers more typical of SAGE.

d. Preliminary ECM Tests

First attempts to measure the performance of the present ESS system under ECM conditions were made on 6 December; a second ECM test was run on 3 January. Both tests used radar data recorded in July 1957 during a Strategic Air Command mission against the Cape Cod System. Program and equipment difficulties during the tests hampered subsequent analysis of the data and rendered the results inconclusive. The tests were valuable as an introduction of ECM techniques to ESS operators, however: in the second tests, when the operators were better able to initiate and monitor the tracks, 21 out of 22 strike aircraft were tracked for a minimum of 19.7 per cent

and a maximum of 88.5 per cent of the time they were in radar coverage. The tests also furnished information to the designers of live ECM tests in ESS scheduled for the next quarter.

C. MEMORY TEST COMPUTER

Additional steps were taken to further increase the effectiveness of MTC to reduce ESS test data: preventive maintenance time was increased to an average of 8.5 hours per day, and virtually all former users except Group 22 and Group 64 were excluded from the use of the machine. As a result, the average reliability of MTC increased from 88.9% last quarter to 96.8%; the mean free time doubled, and the average lost time per interrupting incident was reduced by nearly one half.

During January and February some of the data reduction was transferred to the IBM 704; the work load on MTC, however, remained heavy throughout the period. It was planned to transfer the entire ESS data processing job to the 704 early in the next quarter.

MTC performance, including input-output equipment, was as follows:

Total Computer Hours	2013.7
Per cent Good Time	96.8
Mean Free Time (Hours)	12.7
Average Lost Time per Interrupting Incident (Hours)	0.40

D. WHIRLWIND I

The responsibility for maintaining WW I was transferred to Group 60. Reliability figures for the quarter will be found in Section IX, D of this report.

Unclassified

Unclassified

VACUUM TUBES

GROUP 65

YOUTZ, P., *Leader*

CLOUGH, T. F.

PALERMO, J. S.

Unclassified

V. VACUUM TUBES
GROUP 65

A. SUMMARY

The average life of the Stromberg-Carlson Charactrons in the AN/FSQ-7 (XD-1) consoles has remained unchanged for over a year at about 5000 hours. The Machlett Laboratories' Scriptrons have shown an early life failure of less than 1000 hours. The end-of-life limit of both the Charactrons and Scriptrons is the emission from the oxide cathodes.

The operational data of early production Typotrons in the consoles continues to indicate an average life of about 6000 hours. However, more recent production has shown an early life failure rate of about 892 hours. Deterioration of the storage surface limits the life of Typotrons. Changes have been made in the fabrication and processing of the storage assembly which enable the Typotrons to pass the write-time specification and meet the warranty guarantee but which reduce the operational life of the tubes. The problem is expected to be resolved during the next quarter. Under contract to Hughes Aircraft, Machlett Laboratories completely tooled and started the first preproduction run of 25 tubes to qualify as a second source for the Typotron.

The program at Hughes to develop a storage tube with controlled persistence for the situation display has progressed to the fabrication and evaluation of an all-glass 21-inch tube. Ten electrostatic Tonotrons have been put on the Group 65 life test racks to evaluate the storage surface under simulated SAGE operating conditions.

Development work continued on persistent-emission, solid-state display panels operating under direct-beam bombardment inside cathode-ray tubes. The objective is to determine if these panels can replace the phosphor in the situation-display tubes and replace the storage assembly and phosphor in the digital-display tubes.

B. DISPLAY

1. Charactron

Stromberg-Carlson's production realization rate improved this quarter to 82.2% from 70%. The major production defects continue to be lack of beam uniformity and high voltage leakage. Stromberg-Carlson had established that the appearance of cathodes which produced nonuniform beams indicated general poisoning rather than local ion bombardment. They attempted to remedy this situation by a careful investigation of their in-process methods and equipment. Tubes which had been rejected for high voltage leakage were accepted after the leakage path had been broken by the spark of a Tesla coil. This method distributed the contamination around the tube so that it had no cumulative effect.

Present test specifications for the Charactron do not include limits on:

(1) cathode uniformity for low intensification, or
(2) light output and wavelength requirements of the display.

Stromberg-Carlson is gathering production data on these characteristics and will, with the IBM Display Tube Group, set the limits to be covered in the tube specification.

There are no current production Charactrons going into AN/FSQ-7 (XD-1) or on the manufacturers' life-test racks for long-term life studies. The life-test racks at IBM and Stromberg-Carlson are used to evaluate short-term problems.

2. Scriptrons

As sockets became empty in the situation display consoles in AN/FSQ-7 (XD-1), Scriptrons (Charactrons made by Machlett Laboratories) were installed to gather operational data. Two tubes were removed for low cathode emission. One tube failed at 20 hours, the other tube failed at 3612 hours.

Scriptrons are showing a behavior pattern consistent with that of early production Charactrons and because of the close liaison between Machlett and Stromberg-Carlson, Scriptrons ultimately are expected to have the same 5000-hour average life.

3. Typotron

a. Hughes Aircraft

Purchase acceptance test data on the Typotrons indicated that the product had been shifting toward the limits during recent quarters. The storage surface of recent series tubes enabled them to pass more easily the write-time specifications and still pass all other acceptance specifications. However, this change made meaningless the long term life-test figures which had been gathered previously on a different type of storage surface.

Of the 35 Typotrons removed this quarter, 15 were of the recent G-series production, and all 15 failed because of poor erase time after an average life of 892 hours. Hughes Aircraft and the IBM Tube Display Group have been working on this problem and expect to resolve it during the next quarter.

b. Machlett Laboratories

Machlett Laboratories' final requirement to qualify as second source of the Typotron is to produce 25 preproduction tubes that pass all acceptance specifications. These tubes are to be evaluated and life tested by Hughes Aircraft, who can then certify that Machlett tubes will be interchangeable with the Hughes Typotron. The first group of tubes submitted to Hughes showed poor write and erase time.

C. RECEIVER TUBE DEVELOPMENT AND ENGINEERING

Low-power twin triode (6414); Dual-controlled gate pentode (6888):— IBM has established purchase and inventory schedules on these critical tubes to permit both first and second sources to keep trained teams working continuously on small production runs.

High-power twin triode (2399):— The Chatham Electronic Division of Tung-Sol has been maintaining a satisfactory inventory at IBM. Tung-Sol itself has continued the development of the DT-587, an improved version of the 2339. IBM has been evaluating preproduction samples of the DT-587 as possible replacements for the 2339 in SAGE.

Deflection driver (6161):— Better cathode construction has reduced the previously high failure

rate and the quality of present construction is adequate. RCA has stated that any further improvement will require a development contract.

Phototubes:– These tubes have too much noise to meet SAGE standards of reliability. DuMont Laboratories has stated that a solution of the problem is beyond the scope of normal product improvement and will require a development contract. Further development of these tubes is considered unwarranted at the present time.

D. RESEARCH

1. Controlled Persistence Tube

Hughes Aircraft is under contract to IBM to develop a storage tube with controlled persistence for SAGE situation display. The techniques that had been evaluated in small-diameter storage tubes were used to make one 21-inch, spot-writing storage tube in a metal envelope with a triple flood-gun cluster. The new flood gun gave the expected improvement in storage uniformity, eliminated the coarse moiré between the writing and flood beams, improved brightness, and increased the erase speed. Two all-glass, 21-inch tubes were made with a frit seal after the storage target was assembled in the face panel. The over-all nonuniformity of the storage surface due to residual magnetism which is characteristic of metal tubes is avoided.

2. Tonotron Life Test

The type of storage surface to be used in the controlled-persistence tubes is similar to the storage surface in the Tonotron. Several significant advantages might result if this type of surface were introduced into the Typotron: the character resolution of the Typotron might be improved by the substitution of an evaporated film of magnesium fluoride for the present talc storage surface; the manufacturing tolerances of this new tube might be less critical than those of the present Typotron; tube life would be greater because less beam current would be required. Ten electrostatic Tonotrons have been put on the Group 65 life-test rack to subject the storage surfaces to simulated SAGE operating conditions.

3. Solid-State Displays

One objective of the program is to prepare and study persistent-emission, solid-state display panels operating under direct beam bombardment inside cathode-ray tubes. The panels are a sandwich of electroluminescent and photoconductor layers. Techniques were developed to put these display surfaces on the inside face panel of a 5-inch cathode-ray tube.

Corning Glass Works can provide 5-inch face panels with a transparent stannic-oxide coating upon which the electroluminescent layer can be fused. However, their transparent coatings change during the firing cycles that fuse the electroluminescent layer to the panel. A program has been started to develop a transparent conductive coating that will withstand these firing cycles. The development of a top transparent metallic conductor on the photoconductor for the other electrical terminal of the sandwich panel was continued. The frit sealing technique used in color TV tube fabrication has been successfully applied to the problem of sealing the 5-inch face panel to the funnel of the envelope without damage to the display panel.

GROUP 65

At present the photoconductor will not withstand the usual vacuum bakeout cycle used to process the oxide cathode in cathode-ray tubes. A titanium getter ion pump was developed which can be attached to the tube to continuously pump the tube after it is sealed off from the vacuum system. Five-inch tubes with frit seals, titanium getter ion pumps, and activated cathode-ray tube guns are being evaluated on life test.

SPECIAL STUDIES

GROUP 66

ISRAEL, D. R., *Leader*

CALLAHAN, T. R.
KIRSHNER, H. J.
MANNING, F. F.
ROBERTS, A. J.
STYLOS, P.
THOMPSON, S. L.

GROUP 66

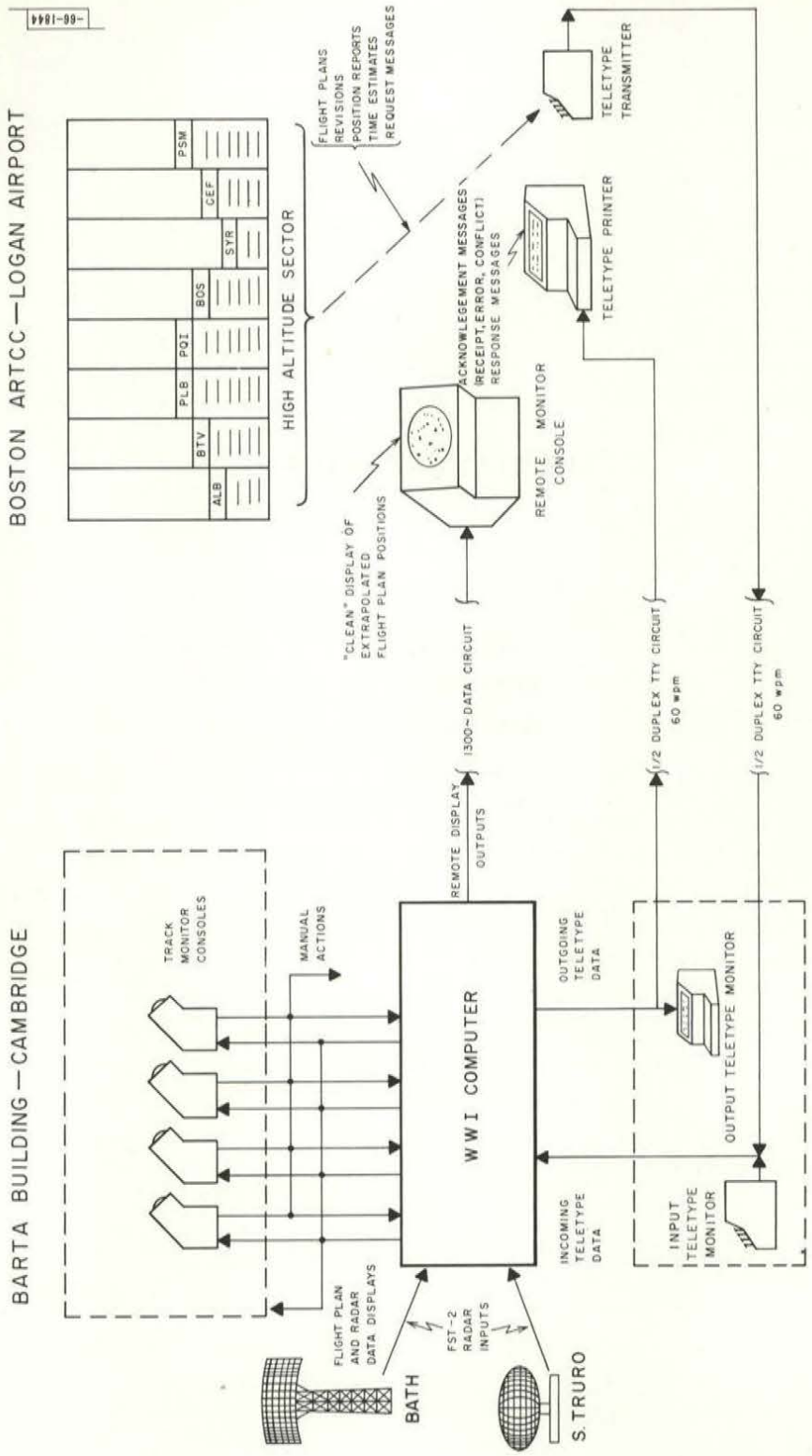

Fig. 66-1. Information flow for CHARM system.

VI. SPECIAL STUDIES
GROUP 66

A. SUMMARY

An experimental system called CHARM (CAA High Altitude Remote Monitor) has been designed to demonstrate and evaluate the integration of and cooperation between SAGE and air traffic control. The Whirlwind I computer will receive air movements information from the Boston Air Route Traffic Control Center (ARTC) via teletype, display it for comparison with long-range radar data from the Bath and South Truro sites, and return a corrected flight plan picture to a special display console at the ARTC. Four track monitor personnel at the computer will correlate extrapolated flight plan positions with the incoming radar data. Contingent on the permission of the Civil Aeronautics Administration and the Airways Modernization Board to install the remote display monitor and teletype equipment at the Boston ARTC, the first operation of the system is expected during the coming summer.

B. CHARM SYSTEM DESCRIPTION

CHARM is an experimental system which employs the Whirlwind I computer to demonstrate and evaluate the ability of a SAGE-like air surveillance system to assist the CAA in air traffic control. The experimental system will prepare and present a remote plan position display of present flight plan positions, updated and manually corrected from radar data, to controllers at the Boston Air Route Traffic Control Center (ARTC) for use in supplementing their present flight progress strip postings.

The information flow in CHARM is shown in Fig. 66-1. Flight plans, position reports, and other air movements information available at the high-altitude sector of the Boston ARTC will be transmitted directly to the Whirlwind I computer via on-line, manually-operated teletype. A number of error prevention, detection, and correction features will be provided in an attempt to yield a flexible and relatively error-free input to the computer. The other major source of aircraft movement information will be long range radar data, filtered by the AN/FST-2 data processors, from the Bath and South Truro sites operated by Lincoln Laboratory.

The computer will process, decode, extrapolate, and store up to 24 incoming flight plans. Periodically, the current position of the flight plans will be displayed to one of four track monitors, along with all radar (search and Mark X) data received within the past minute. The monitors will be permitted to make adjustments in the extrapolated flight plan position so as to correlate the position with the incoming radar data.

The correlated and corrected flight plan positions will then be encoded by the computer, transmitted back over a 1300 pps circuit to the Boston ARTC, and presented on a remote display console. Predicted positions of 2.5, 5, 7.5, and 10 minute intervals will also be shown. This console, designed by Group 63, uses a Tonotypotron display tube with a controlled persistence of up to several minutes and enough brightness for daylight viewing. The computer will also prepare and transmit a number of different teletype messages to the ARTC which will supplement the information on the remote display.

GROUP 66

The design of CHARM started in late January of this year, and by the end of the quarter was essentially complete. All equipment is now available, and the completion of the computer programming is expected during the summer. Discussions with the Civil Aeronautics Administration and the Airways Modernization Board to secure their permission and cooperation in installing and utilizing the remote display at the Boston ARTC are proceeding satisfactorily.

ADVANCE SAGE PROGRAM DEVELOPMENT

GROUP 67

ZRAKET, C. A., *Leader*

BACHELDER, J. L.
BAGLEY, P. R.
BAILEY, D. L.
BENSLEY, E. H.
BRISCOE, H. W.
BUDD, ELEANOR J.
BURROWS, J. H.
BYRNE, W. J.
CHANDLER, A. R.
CHOMSKY, CAROL S.
CLAPP, ELIZABETH S.
CRADDOCK, MARCIA J.
CURTIS, R. G.
DAVIS, R. C.
DIMEO, R. V.
EARL, D. B.
FERGUSON, MARY E.
FRACHTMAN, H. E.
GOCHMAN, H.
HAGER, L. S.
HALPERN, BARBARA M.
JONES, K. L.
LEVENSON, JUDITH A.
LUNDBERG, E. D.
MARKO, J. T.
MEAD, W. H.
MILBERT, A. J.
ORNSTEIN, S. M.
PENDERGRAFT, E. D.
RISING, H. K.
SEDGEWICK, NORMA L.
SMITH, SONIA F.
STONE, JUDITH H.
THOMAS, D. J.
THOMAS, L. M.
VANDERBURGH, A., JR.
YNTEMA, MARY K.

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VII. ADVANCE SAGE PROGRAM DEVELOPMENT
GROUP 67

A. SUMMARY

In a study based on an assumed system load, the track capacity of the 1959-60 SAGE system was predicted to be 200 – 300 tracks, half of which can be interceptors or missiles. A program was written to produce a computer-synchronized tape of live radar data for use in evaluating experimental tracking programs. The track-while-scan (TWS) portion of the SAGE non-real-time (SNORT) simulation was assembled and used for tests of the SAGE direction center active (DCA) program. Dual tracking, an improved logic for tracking maneuvering aircraft, was assembled, costed, and readied for detailed evaluation next quarter.

The findings of the 1959-60 SAGE program cost evaluation study are that the computer program requirements for BOMARC and Nike missiles, century series interceptors, the automatic target-battery evaluation feature, and emergency (Mode II) capability will not be excessive, and that the program should be designed to accommodate 300 tracks to provide adequate system capability over a wide range of loads.

Using TWS, the SAGE automatic tracking function was examined and these conclusions were made: the "quick fix" (interim modifications to the automatic tracking program) increases kill capability and is adequately stable for straight-line tracking; the program frame time should be kept under 21 seconds; and relatively dense, maneuvering raids present impossible situations to the automatic tracking program.

B. PROGRAM COST EVALUATION OF 1959-60 SAGE*

A study has been completed to predict the operating time and storage requirements of the SAGE DCA program in the 1959-60 period. BOMARC and Nike missiles, the automatic target-battery evaluation (ATABE) function, century-series interceptors, and emergency (Mode II) capability were assumed as the major additions to the present DCA program. The loads used in evaluating the air situations were derived from detailed maps of the New York Sector. In the heavy load, for example, a hostile force of 450 planes (flying in six waves with three-mile separation) was brought into the sector, while a combined force of about 300 manned interceptors and about 200 BOMARCs was directed against the raid. The results of the study indicate that the program cost of the new functions should not be excessive and that the track processing capability of the program will vary from 200 to a maximum of 300 tracks simultaneously in the system. Half of the 300 tracks could be interceptors, either BOMARC or manned in any combination. The conclusions of the study are dependent upon the assumed system load: in addition to the number of aircraft being tracked, system load is directly affected by such variables as the number of switch actions taken per frame, the number of tracks that are crosstold, and the number of digital data requests per frame. Key assumptions are (1) an 18-second program frame; (2) a 25% coding improvement

* 6M-5608, "Summary of Cost Evaluation of the 1959-1960 Revised SAGE Program," by H. K. Rising, E. D. Lundberg, J. T. Marko, and H. Gochman.

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throughout existing subprograms of the present model as estimated by SDC; and (3) a memory cycle time of 6 microseconds.

It is recommended that the computer program be designed to accommodate 300 tracks, rather than some smaller number, to provide adequate program capability over a wide range of system loads. A small (5%) reduction in track carrying capacity under heavy load conditions would result, but the system would be able to carry that maximum number of tracks under light load conditions.

C. AMIT: A COMPUTER-SYNCHRONIZED RECORDING PROGRAM FOR RADAR DATA

A detailed analysis of tracking programs using recorded radar data has been made easier by a recording program developed during the quarter. The AMIT (Ampex to IBM Tape) recording program transfers free-running Ampex recordings of radar data to computer-synchronized IBM tape recordings which can be combined with switch actions to make a realistic, repeatable input tape. In this form (i.e., with switch actions permanently synchronized with the radar data) the recordings will be used as computer inputs to compare the relative effectiveness of experimental tracking programs under controlled conditions.

AMIT overcomes a significant limitation previously encountered in tracking studies. While the behavior of tracking programs could be observed under controlled conditions using simulated radar data and switch actions, these inputs could not be made realistic enough for a rigorous evaluation. Recorded live radar data, on the other hand, provided the realistic data input, but could not be consistently synchronized with track monitor switch actions during a test. The new system of recordings solves this problem as follows:

(1) Ampex-recorded, live radar data is processed by the AMIT program and recorded on IBM tape in one-second blocks.

(2) The IBM tape is then used as an input to the computer while the DCA program is running. Actual switch actions are then taken (track initiations only) and the resulting output is recorded on a master operational tape.

(3) The IBM tape is then combined with the switch actions of the master operational tape by means of a program similar to AMIT.

(4) Finally, the tape output resulting from the above process is used as an input to the tracking program under study.

In addition to the basic system described above, a processing program was written which gives the programmer an opportunity to monitor and select specific types of radar data. The processing program operates with AMIT while the IBM recording is being made. It will select for display or printout at specified intervals (1) all radar data, (2) all radar data within specified search areas, (3) all radar data from specified sites, or (4) various combinations of these data inputs.

D. SNORT-TWS

The track-while-scan (TWS) portion of the SAGE non-real-time (SNORT) simulation was completed and tests using it were begun. SNORT is being written by Lincoln Laboratory, Boeing, and IBM to examine the SAGE automatic tracking and guidance functions, using BOMARC, manned

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interceptors, and other missiles. Using TWS, a series of tests was run to evaluate the relative merits of several variations in the logic and parameters of the SAGE automatic tracking function in dense, or raid formations. Three formation types (trail, abreast, and box) and two separation distances (4 and 7 miles) were used. In addition, tests were run with fixed subframe lengths of 5, 6, 7, and 8 seconds.

Although the input data did not have all the desired characteristics for an adequate test of the system, the following conclusions could be drawn:

(1) Straight-line tracking with "quick fix" is adequately stable.

(2) If further improvements in the automatic tracking program are needed, the adjustment of parameters will probably not be as beneficial as "quick fix" has been; stability, however, might be improved.

(3) The program frame time should be kept under 21 seconds with the present logic.

(4) A maneuvering raid formation with aircraft separation of 4 miles or less presents impossible situations to the automatic tracking program, especially if the formation is of the box type. A new logic or proper track monitor actions are suggested as probable remedies.

E. DUAL TRACKING

Dual tracking, a modified logic for the ESS DCA program which will improve the tracking program's ability to differentiate between spurious radar returns and maneuvering aircraft, was fully assembly tested and prepared for evaluation tests. The cost of the program in terms of storage space and response time was estimated,* with these as some of the significant requirements.

(1) Additional drum storage, 1333 registers.

(2) Additional table storage, 600 registers (6 registers/track in the 100-track system).

(3) Additional input-output time, .012 seconds for any track capacity.

In the next quarter, dual tracking will be further tested, its parameters adjusted for best performance, and quantitative comparisons will be made with the present tracking logic. The newly developed AMIT (see above) system will furnish the live radar background. The simulated aircraft radar data (SARD) tape developed by Group 61 will be the simulated input.

* 6M-5585, "Costing Estimates for Dual Tracking," by A. J. Milbert.

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SYSTEM OFFICE

GROUP 68

BROWN, D. R., *Leader*

BRAGAR, P.
COLLINS, L. B.
CROKE, J. J.
GINSBURG, S. B.
GIORDANO, J.
HOLDEN, W. E.
IPPOLITO, V. O.
JOHNSON, F. B.
MAY, J. P.
OGDEN, W., JR.
PARKINS, T. R.
RUPP, A.
SHOREY, R. R.

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VIII. SYSTEM OFFICE
GROUP 68

A. SUMMARY

A committee was established to insure that changes proposed to the design of the initial SAGE system are adequately evaluated by the design and implementation groups and agencies concerned with the initial system. The committee, consisting of representatives from Groups 62, 64, 67, 68, and 22 of Lincoln Laboratory, the ESS maintenance section of the System Development Corp., IBM, and the 4620th ADW, processed some 40 design changes during the quarter.

Program and equipment changes in Model 2 were described which will make possible the initial testing of AN/FSQ-7 with an AN/FSG-1 Missile Master. Model 2 of the DCA program is being assembled primarily for this testing, which is scheduled to begin in the Washington Sector in October 1958.

In cooperation with other groups and agencies, the major increases in capability of the 1960 SAGE System were designed. The new features include AA operation, BOMARC IM-99A, century-series interceptors, emergency capability (Mode II), and the Mark X Selective Identification Feature (SIF).

B. THE INITIAL SAGE PROBLEM COMMITTEE

The Initial SAGE Problem Committee (ISPC) was established in December to provide adequate evaluation of proposed changes to the SAGE System by the design and implementation groups and other agencies involved. Its members include Groups 62, 64, 67, 68, and 22 of Lincoln Laboratory, IBM, the SDC ESS maintenance section, and the 4620th ADW. The changes affect the operational specifications of the initial SAGE system and the design specifications of the 1960 system. By the end of the quarter, the number of changes proposed had reached 278. A proposed change is processed as follows:

(1) The proposed change is reviewed to determine whether or not it represents a true change to the operational specifications.

(2) The System Office studies the proposal and writes a recommendation, describing the changes that will have to be made to implement it.

(3) The System Office recommendation is reviewed by the ISPC and concurrence signatures are obtained from representatives of IBM, SDC, the 4620th ADW, and Group 68.

By the end of the quarter the ISPC had reviewed and processed some forty proposed design changes. Changes involving equipment (other than variable display equipment) and those involving a major change to the DCA programs were further processed for release by TIR through the regular procedures of the Lincoln Production Coordination Office. Fifteen of the ISPC changes were verified by SDC for inclusion in Model 2 of the DCA program. Descriptions of changes processed by the ISPC are included in the Group 68 biweekly reports, 6M-5486, 6M-5552, and 6M-5563. A complete listing of all changes, as well as the present status of each, is given in the SOER Status Report published periodically by the System Office.

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C. MODEL 2 OF THE DCA PROGRAM

Model 2 of the DCA program is being assembled primarily to provide a program for the initial testing of AN/FSQ-7 operation with the AN/FSG-1 Missile Master. The only major changes to the program are to provide this capability. Model 2 will be installed in the Washington Sector for the testing beginning in October 1958. The program and equipment changes are described in System Office Recommendation 6M-5297 (TIR #1-236).

D. THE 1960 SAGE SYSTEM

The design of major features to be included in the 1960 SAGE System was virtually complete by the end of the quarter, and the documentation of them was begun. The features are: SAGE operation with Army air defense command posts; SAGE control of BOMARC IM-99A; SAGE control of manned interceptors (century series); emergency capability (Mode II); IFF Mark X (SIF); time-division data link; combat center operations; the SAGE System Training Program (SSTP). The capability provided by these features, their present status, and additional requirements needed for their implementation will be described in the "1960 SAGE System Status Report" to be published next quarter. Some of the features covered are discussed in the following sections as well as a series of interim measures which will lay the groundwork for their implementation in 1960.

1. SAGE Operation With AADCP's

SAGE capability for operating with Army air defense command posts (AADCP's) is being developed in several phases. The first phase, operation with manual AADCP's, is being tested now in ESS: track information is sent from the direction center to the AADCP at Fort Banks over teletype and telephone lines. Compatability between the manual AADCP system and the automatic functions of ESS was provided by modifications in communication formats and procedures.

The second phase is scheduled to begin in October 1958 in the Washington Sector* when a SAGE direction center will operate with an AADCP equipped with an AN/FSG-1 Missile Master. Model 2 of the DCA program will provide the capability for the AN/FSQ-7 at Fort Lee to operate with the Missile Master at Fort Meade. Compatibility between the 1300 bits per second transmission rate of the SAGE direction center and the 750 bits per second receiving rate of the Missile Master will be provided by a digital data converter; other equipment and communication changes will also be required.

The third phase in the development of SAGE – Missile Master operation will begin with Model 3 of the DCA program which is presently scheduled for operation on 1 February 1959. The number of AADCP's with which a SAGE direction center can operate will be increased from two to four in Mode I (normal) and to six in Mode II (emergency) in any combination of manual or Missile Master AADCP's. SAGE direction centers will also be capable of switching from

*6M-5297, "System Office Recommendation: Implementation of SAGE/Missile Master Integration in the Washington SAGE Sector," by J.J. Carson (SDC), dated 20 December 1957.

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Missile Master to manual operation with an AADCP in the event of Missile Master or ground-to-ground data link failures. The capability to operate during non-alert conditions with only one antiaircraft team on duty at a SAGE direction center will also be provided.

In the fourth phase, SAGE direction centers will have the capability to automatically assign targets to NIKE batteries through the Missile Master. This feature, called ATABE, is currently being designed and is tentatively planned for first operation in the Detroit Sector in 1960. The ATABE feature in the DCA program will make possible target assignment to a battery by switch action at a SAGE direction center.

2. SAGE Control of BOMARC IM-99A

Although no interim capability for SAGE control of the BOMARC IM-99A is provided before 1960, the incorporation of the feature has already begun. The crosstell input channels necessary for ground-to-ground communication from the BOMARC base to the direction center will be available as a result of a redesign of the crosstell input system. A description of the SAGE output sections to provide for operation with frequency-division and time-division data link (FDDL and TDDL) has been released by TIR.* In some sectors, during the phasing of TDDL, both types of data link will be in use. SAGE output equipment will be capable of operating with manned interceptors as well as with BOMARC's. FDDL output sections will be retrofitted in those sectors that will use FDDL-equipped BOMARC's beginning with the Gunter Direction Center which is scheduled to control the first test firings to demonstrate SAGE-BOMARC compatibility in the summer of 1959. The results of these tests will form the basis for the design of simulated firings during the operational testing of the McGuire Direction Center late in 1959.

3. Manned Interceptors

The following increases in SAGE capability for the control of manned interceptors are planned for Model 3 of the DCA program:

(a) An increase in the maximum speed at which interceptors can be tracked from 1.2 mach to 1.9 mach

(b) A provision for selection of armament by switch insertion

(c) An increase in the accuracy of armament lead computations

(d) The provision for automatic insertion of the optimum attack parameters of the selected armament into the intercept calculations

(e) The provision for a two-speed mission capability (combat and cruise) and for transition between them.

Other improvements in Model 3 will make provision for improved voice data link, operation with frequency-division data link, and new armament to be carried by century series interceptors.

4. Mode II (Emergency) Capability

Mode II (emergency) capability will be provided for in Model 3. Under this mode of operation the responsibilities of a disabled SAGE direction center will be taken over by the direction centers

*6M-4460, TIR 1-200, "The Addition of BOMARC Frequency-Division Output Sections and Time-Division Output Sections to AN/FSQ-7's," by System Office, dated 1 July 1957.

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of the two adjacent sectors. Except for the additional burden that Mode II will place on the communications (crosstell input system and ground-to-ground output channels) between the active sectors and the airbases, AADCP's, and data link transmitters of the disabled sector, Mode II capability is primarily a problem of designing the program within the capacity of the computer. System tests and operator training will be required to handle the greater load that will result during Mode II operation.

5. IFF (Mark X) Selective Identification Feature (SIF)

The selective identification feature (SIF) is scheduled to become operational in the continental United States on 1 January 1959. Eventually the AN/FST-2's at the long range radar sites and the RAPPI equipment will be modified to process the SIF code and message labels in accordance with ADC employment plan 57-3285.* An interim measure is being designed to provide for SAGE operation with SIF from 1 January 1959 until the above modifications become operational.

6. The SAGE System Training Program (SSTP)

The design of an SSTP is primarily the responsibility of SDC. The initial SSTP is included in Model 1 of the DCA program and added features are expected to be provided for in Models 2 and 3. In April 1960 major changes are expected to be made to equipment in the TBS room and the first dual machine training is expected to be provided.

*"Plan for Employment of Mark X Selective Identification Feature (SIF)" USAF ADC 57-3285 (26 April 1957).

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ADMINISTRATION AND SERVICES

GROUP 60

PROCTOR, J. C., *Leader*

FALCIONE, A. M., *Associate Leader*

ALLEN, D. C.
ATTRIDGE, W. S., JR.
BROCK, L. T.
ESSLER, G. J.
GROVER, C. S.
HAZEL, F. P.
HEDISON, H. H.
HEIDLER, G. R.
HILL, A. P.
HODGDON, H. W.
KATES, W. A.
LINEHAN, L. H.
MILLER, R. C.
MORLEY, H. B.
SERGIO, L. S.
SMITH, A. R.

GROUP 60

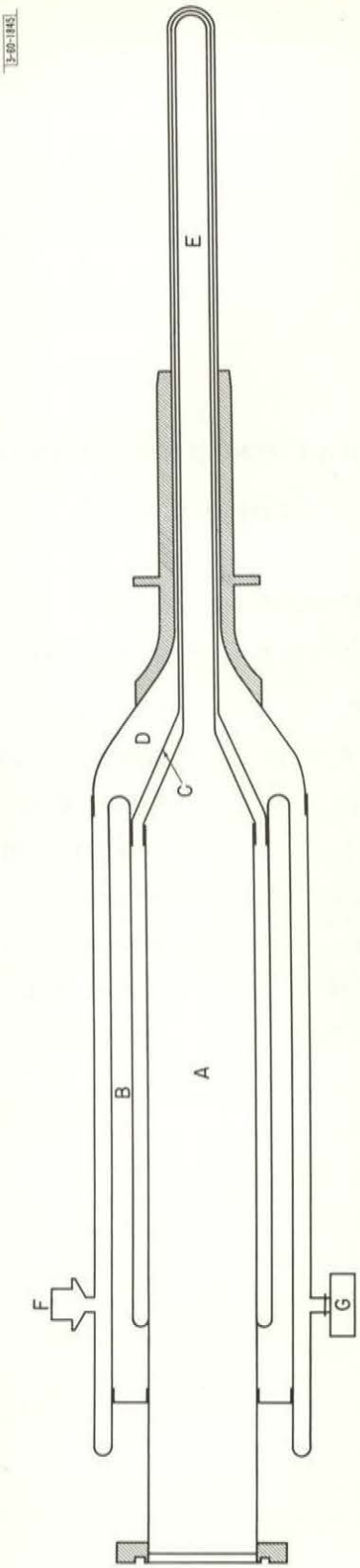

Fig. 60-1. Metal helium dewar. The principal features indicated on the diagram are: A—Helium section; B—Nitrogen section; C—Perforated and copper heat sink extending from nitrogen section down to and around working section; D—Evacuated chamber; E—Working section; F—Evacuation port; G—Pressure relief head.

IX. ADMINISTRATION AND SERVICES
GROUP 60

A. SUMMARY

The activity of Group 60 is mainly of a supporting nature. The General Engineering Section, which furnishes design, fabrication, and assembly services to the division, provided several pieces of equipment to facilitate the study of magnetic materials at low temperatures and assisted in the design of a high-speed, magnetic tape transport for ultimate use in a computer-integrated tape library system being developed by Group 63. The joint card- and tape-processing facility handled 3.2 million cards in support of the users of AN/FSQ-7 (XD-1) and the IBM 704. The responsibility for maintaining the Whirlwind I computer was taken over from Group 64.

B. GENERAL ENGINEERING

1. Equipment for Low-Temperature Studies

Dewars, dewar equipment, resistance thermometers, and sample holders were made for use in the study of magnetic materials at low temperatures carried on by the physics section of Group 63. Of particular interest is a dewar made of copper (working section) and stainless steel (upper section). Several design features make the metal dewar easier and more efficient to use than the conventional glass type:

(a) The working section is larger (11/16-in. I.D. vs. 3/8-in. I.D. for a glass dewar of the same O.D.), because the copper walls are thinner than glass, and the nitrogen bottle does not extend into the narrow section (see Fig. 60-1). Larger samples and special sample holders (such as a heating coil and thermometer to obtain temperatures ranging from 1.8°K to roughly 77°K) may be used. Above this temperature, a conventional nitrogen dewar is normally used. The inner bottle holds enough helium to double the maximum duration of the experiment.

(b) The metal walls are more exact, both in thickness and in straightness, making possible closer tolerances. The working section can be rotated without fear of disturbing perpendicularity.

(c) The copper walls are less permeable to helium than is glass, thus the vacuum is preserved longer.

(d) The vacuum is easily restored using Laboratory equipment; thus the delay usually encountered when a glass dewar is sent out for evacuation is avoided.

2. In-Out Equipment for TX-2 and TX-0

Design assistance and fabrication service was given Group 63 in the development of a high speed, computer-integrated, tape transport for a planned magnetic tape library system in TX-2. The transport mechanism is simple and versatile: there is no capstan, the tape being driven in read, write, and search modes by two conventional three-phase motors. The tape guide is shaped to provide a cushion of air under the tape, minimizing wear at the high speeds (up to 1000 ips) employed.

Fig. 60-2. High-speed tape transport for use with TX-2 computer. The large tape guide is designed to permit high tape speeds with minimum wear. Photoelectric cells at upper corners sense end of tape when the light in cylindrical housing (center) reaches them through transparent leaders at either end of the tape.

A Ferranti tape reader used with TX-0 was modified to increase its reliability. Photodiodes in the read element were replaced by photo-transistors and each was furnished with its own convergence lens. The modified optical system is more resistant to jarring, and the photo transistors produce a stronger, sharper output waveform.

C. CARD- AND TAPE-PROCESSING FACILITY

The joint facility set up last quarter to process computer program materials for users of AN/FSQ-7 (XD-1) and the IBM 704 reports 3.2 million cards processed and 1134 hours of line printer usage. The major items in support of ESS and SAGE included: about 30% for data reduction of shakedown and evaluation test results; 60% for advance program development; and 10% for equipment maintenance and operator training.

D. WHIRLWIND I (WWI)

In January the responsibility for maintaining the Whirlwind I computer, located in the Barta Building, M.I.T., was taken over from Group 64. During the quarter some staff members and technicians were transferred to the Memory Test Computer (MTC) to assist in the intensified maintenance of that computer.

WWI performance, including input-output equipment, was as follows:

Total Computer Hours	1398.1
Per cent Good Time	98.6
Mean Free Time (Hours)	40.0
Average Lost Time per Interrupting Incident (Hours)	.43

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